MULTI-LEVEL INFORMATION SYSTEMS IN EDUCATION

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FOREWORD

This investigation began as an investigation of administrative data systems in education, with the aim of designing computerized systems which would facilitate such administration, and also provide data for research purposes. As we progressed, however, several points became apparent. First, it was apparent that the principal problems in schools did not arise from the current organization of data systems, and would not be solved by the introduction of computerized systems. Minor gains might be made, but this seemed hardly sufficient to warrant devotion of staff attention and educational resources to such computerization. There have been a number of projects involving computerization of administrative functions, some of which are reviewed in Section II. These have often been mildly successful, but they seem not to have brought important benefits to school functioning, with the exception of possibly better student scheduling than when schedules are made by hand.

Second, at one point in the investigation, it became clear that the greatest value of such computerized systems would occur in extremely large school districts, in which the number of students and staff are so large as to overwhelm the administrative mechanism. It became apparent that automated data systems in these districts might merely allow an already depersonalized system to become more so, and to grow into even larger units through amalgamation (with the amalgamation sometimes justified in terms of "administrative efficiency," and sometimes justified to spread capital costs of computer administrative equipment).

Third, our aim of "providing data for research purposes" seemed also somewhat irrelevant to school functioning. Few research results ever find their way back to school districts and schools to affect decisions. Their principal destination is scholarly publication, and they often remain there.

In reaction to these points, there emerged a different conception of data systems in education, and of the educational system generally.

This is the conception of many parties with legitimate interests in education, both within the formal organization of school districts, and outside, and of an information system that would aid the decisions of these various interested parties. The resulting conception and design is one which bears little similarity to management information systems that are designed to serve the needs of an hierarchical organization. It is explicitly designed as an information system for multiple users, from parents and children to legislators, and including persons in the organizational structure of schools, from teachers to superintendents. It is designed for the emerging pluralistic structure of American education, in which all parties to education make responsible choices; and it is designed to aid in the emergence of such a pluralistic structure, and to aid such responsible choice.

J.S.C. and N.L.K.
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INTRODUCTION

This report presents an examination of data systems in education, and provides a framework through which such data systems can provide the basis for a powerful information bank to aid educational decisions. In the past, records in schools have been maintained as physical files, in a form which allowed easy access for the principal administrative use to which the records were put. As schools and school systems have grown in size, however, the need for more efficient handling of these records has become pressing, and many schools and school districts are developing computerized data systems.

With these computerized administrative data systems, it becomes possible to use records for many purposes other than the principal administrative use for which they are maintained. Because the records are electronically rather than physically stored, they can be sorted, aggregated, merged, and subjected to statistical data reduction in many ways for many purposes.

In particular, such facilities make it possible to erase the artificial distinction between administrative uses of information and research or evaluation uses. Administrative uses of information are uses for decisions, ranging from decisions about individual cases to general policy decisions. Research and evaluation in schools is also carried out to aid in such decisions. However, with the artificial distinction between administrative uses and research uses, necessitated by past methods of record maintenance, research has ordinarily required collection of special data on a "project" basis, at large costs and with uncertain value for policy decisions. The opportunity created by computerized data systems is an opportunity to integrate research uses and administrative uses of information to aid in educational decisions at all levels.

Apart from this opportunity created by the change in technology, there are two factors which create a pressure for broader uses of educational information than in the past. The first is increased consumer

power in education, as parents and parent groups exert pressures for release of information previously restricted to educational administrators. The second is increased focus on the outputs of education, the actual performance of children, rather than solely the inputs of resources into schools. These two factors together are creating increasing demand for broad evaluative uses of information that previously served only internal administrative uses in schools.

Problems exist in realizing this aim, however. First, the data systems must be appropriately designed from the outset to bring the power of the information to bear on educational decisions. There are numerous kinds of decisions to be made, and the system must be designed in cognizance of these different kinds of decisions. Second, there are problems of interests of different parties in education, and the way information will be used to implement these interests. Information is power, and access to information in educational data systems affects the power of various parties to the educational process. Differently designed systems will place information in the hands of different parties, and it is necessary to recognize the power implications of differently designed systems. Third, there are numerous other considerations in the design of computer data systems: cost, ease of use, flexibility and adaptability to new uses; compatibility with instructional uses of computers; and modularity of design to allow incremental introduction of a new system.

This paper will focus on these problems in the design of educational data systems for administrative and research-evaluation purposes. Because attention will be directed to the integration of administrative uses of information and research-evaluation uses, a number of important aspects of computer usage in administration will be discussed very little. Payroll calculation is a straightforward clerical task which computers currently perform in some school districts. However, because it is not a computer function related to administrative decisionmaking, little attention will be paid to it.

THE INTERESTED PARTIES TO EDUCATION

To begin examination of data systems in education, it is perhaps most useful to begin from the "wrong way round," identifying the

interested parties and examining the interests of each and the kinds of decisions of each. Only after this will we look at data systems in schools as they currently exist and as they can come to exist under existing computer technology.

There are a number of interested parties in education who make decisions that affect educational outcomes. For present purposes, it is useful to distinguish the following interested parties: parent, child, teacher, principal, superintendent, state government, federal government, neglecting finer distinctions such as state education department as distinct from state legislators. These different parties are interested in different kinds of information -- in information about performance of particular students, types of students, or students in general; in information about effectiveness of particular programs (or curricula, teachers, or schools), or in effectiveness of certain types of programs, curricula, teachers and schools. Each has an interest in access to certain kinds of information (for example, parents have an interest in access to information about the effectiveness of a particular teacher or school), and each has an interest in restricting access to certain information (for example, superintendents have an interest in restricting access to information on school-by-school measures of student performance, or parents have an interest in restricting access to their child's measures of performance).

To gain some idea of the kinds of decisions that each party makes, and the kind of information useful to him making these decisions, it is useful first to describe the general class of decisions which concern us here: decisions about <u>the exposure of students to possibly effective educational environments</u>. Within this class, some decisions concern individual students, some concern students with particular characteristics (teachers with high verbal skills, phonic reading methods, schools with a given class size), and some concern general student achievement apart from the specific environment. These classes of decisions can be described by Table 1 which shows nine kinds of information about performance.

Table 1

TYPES OF INFORMATION FOR USE IN EDUCATIONAL DECISIONMAKING

	Performance by: Individual Students	Characteristics of Students	All Students
Particular Environment	1	2	3
Characteristics of Environment	4	5	6
Independent of Environment	7	8	9

In Table 1, the label "particular environment" refers to a specific case: a certain teacher, Jane Jones; a certain curriculum, the PSSC physics curriculum; a certain school, P.S. 86. The label "characteristics of environment" refers to variables that characterize the educational environment: teacher characteristics, class size, etc. A similar distinction concerning students exists between the first two columns of the table. The cells represent given types of information upon which decisions can be based. For example, information about the performance of students with high initial achievement in physics, in a physics course with the PSSC curriculum is information of type 2 in the table.

The term "research" is ordinarily confined to information of types 5 and 6, showing effects of environmental characteristics on student performance. "Evaluation" is sometimes used in the same way, but more often refers to information of types 2 and 3: effectiveness of particular programs (often experimental or demonstration programs) on performance of students in general, and the performance of particular groups of students (e.g., students with initially low reading scores). What is important to recognize, however, is that these types of information constitute only a fraction of the information on student

performance necessary for educational decisions. Thus to focus on research and evaluation as ordinarily defined, without initial attention to the types of decisions made by the various interested parties artificially restricts the frame of reference.

The decisions of state and federal governments in education are decisions about funding types of programs, both in their impact on students in general, and in their impact on students with particular characteristics. For these decisions, they need information of types 5 and 6 in the above table. Decisions of school boards and school superintendents are also concerned with this general knowledge about effects of types of school environments on students, but they are also very much concerned with information of types 2 and 3. Their decisions are a mixture of decisions about particular environments and general types of environment. They are often decisions about whether to continue a particular program, or a particular curriculum, whether to make a given person a school principal; but they are also decisions about whether to institute a program with given characteristics, what types of teachers to hire, what kinds of physical facilities to construct. The information they need for these latter types of decisions (information of types 5 and 6) ordinarily transcends their districts, for the information base in their district may not contain the relevant experience.

Principals' decisions ordinarily concern particular programs, particular teachers, particular teaching aids, so that the information they need is of types 2 and 3: information about the effectiveness of those particular learning environments in their school, information which will help them decide whether to continue or to stop the program in question. In some cases, their decisions concern individual students, requiring information of types 1, 4, or 7, to decide on the disposition of students who present special problems.

Teachers and counselors most often make decisions about individual students, and require information on performance of individual students, of types 1, 4, and 7. Counselors are also concerned with decisions about the probable performance of certain types of students in certain types of environments, (e.g., what types of students perform best with

certain types of teachers), or what types of students are successful in certain kinds of colleges), requiring information of type 5. Teachers also make decisions about the performance of certain types of students in a particular environment (e.g., class discussion or class projects, drill or games), for which information of type 2 is necessary. More broadly, teachers also need information of types 5, 6, and 8 as a background for planning everyday activities. This general information is the sort that teachers get or should get during their training.

Parents and children are first of all interested in the individual child's performance, information of type 7; but in making decisions about what school to attend, what teacher to try to get, they need information of types 1, 2, 3, and 4. Insofar as choices of parent and child are expanded, through allowing a greater range of choices of schedules and even of schools, information of types 5, 6, and 8 as well is necessary for making these choices wisely.

From this assessment of decisions at various levels, requiring various types of information, it is clear that any data system which would satisfy these needs must be both technically and administratively complex. The technical complexity lies in the fact that raw performance measures of students will not serve most of these information functions. To know the effectiveness of educational environments for performance requires detailed statistical analyses of the student performance under different educational environments. The administrative complexity lies in the question of control over and access to various types of information. Information cannot be totally controlled at a given level within the educational hierarchy, for it would become useful only for those at that level; and it cannot be wholly contained within the school organizations themselves, for it would be of no use to federal and state governments or to parents and children. To obtain general information of types 5, 6, and 8 requires information from many school districts.

This examination of types of information and levels of decision-making describes the dimensions of the problem. The next section gives an overview of the characteristics of emerging computerized data systems in schools and school districts. These data systems have on the

whole been developed merely to automate the existing uses of school records, to aid school staff and administrators. But despite the limited uses for which they have been designed, they constitute the nucleus from which information systems to serve the various levels of decisions described above can develop.

II. SURVEY OF EXISTING EDUCATIONAL DATA SYSTEMS

The use of computers in educational administrative activities has increased in the past few years, but, relative to business and industry, this speed of incorporation of computers has been slow. There are several possible reasons for this. One could argue that the problems in educational administration are somehow not amenable to computer application. However, the procedures in educational administration have many counterparts in business where computers are being used effectively.

A more plausible reason for the slow rate of computer infiltration is that schools are habitually and notoriously short of funds. The current fiscal crisis in the Los Angeles city system resulting in elimination of extra-curricular programs, is one example of the limitations on budgets. Rental of a moderate size computer costs between \$2000-\$4000 per month. This expense does not include salaries of programmers, key punch and other operators needed to support such a system. This range of expenditure is very difficult to justify unless clear benefits result from it. (It is more difficult to "cost out" the current manual way of record-keeping, since one would have to know the percentage of time teachers or clerks spend on these activities and what would be gained in other areas by freeing them from these tasks.)

There is some resistance to the administrative uses of computers by those who feel very keenly the anonymity and dehumanization of daily life. Often the computer symbolizes this impersonal aspect of modern life for many persons. (Recall the placard of a Berkeley student striker which read, "I am a student, do not fold, bend or mutilate!") Education, as an enterprise wholly for and about humans, is particularly sensitive to this concern. The introduction of a machine appears somehow debasing to the enterprise as a whole, and out of place.

David Nasatir (9) in an examination of resistances to innovation in education argues that the structure of American education makes adoption of innovation in education very difficult. One important function of the schools, he argues, is the socialization of its students and the inculcation of the broader goals of society. Sustaining

and perpetuating a tradition gives the school a feeling of moral righteousness about its activities. Therefore any attempts at change made by an outsider, i.e., one not invested with this moral righteousness, are likely to go unheeded.

However, Nasatir argues, the personnel currently within the system are not likely to bring about drastic changes. Teachers are recruited by people within the system, and thus selection of persons who will preserve the system is most likely. In short, Nasatir concludes that there are not many good ways to break into the system, and thus is pessimistic about the adoption of innovations by the schools.

In opposition to these obstacles, there are compelling forces at work to bring about the incorporation of computers into education. Some relief from the onerous task of maintaining the multitudinous forms required in school administration is clearly needed. The volume of data, the repetitive and time-consuming nature of many of these tasks are factors pointing toward potential computer application. This volume of data continues to grow with increased enrollments.

In addition, the schools are now maintaining types of information not necessary in the past. The introduction of curricular changes and attempts at new organizational patterns require keeping data to evaluate the effectiveness of the programs.

The growth of interest and concern over the quality of education has led to a demand for information from the schools. As one example, pressure from local community sources is increasingly inducing school districts to publish school-by-school scores on standardized tests. This need for data and procedures to evaluate the functioning of the school systems is voiced by a variety of parties. Tax-payers, state and federal governments want a good return on their investment; researchers want data to learn about the school and learning process; civil rights leaders want to demonstrate the inadequacies of inner-city schools; majority parents want to know if the bussing in of minorities is detrimental to their children.

1. PROCEDURES IN EXISTING DATA SYSTEMS

Information about current data systems comes from available literature and from interviews with school administrators of four school districts

in the Los Angeles area. Table 2 identifies the projects surveyed and briefly describes each project. The numbers in parentheses in the first row refer to items in the bibliography giving information about the system described in that column. Although administrative data systems entail collection and maintenance of data for all facets of a school district's activities, this survey concentrates exclusively on pupil personnel data systems. There are five major areas included in pupil personnel systems: scheduling, attendance reporting, grade reporting, standardized test reporting and master file maintenance.

The data bases maintained by the various districts for the pupil personnel systems are very similar. Maintenance procedures differ, however, according to the availability of types of data processing equipment. Table 3 is a summary of procedures in use by the systems surveyed, and the pages below describe these procedures.

1.1. Scheduling

The process of matching subjects, students, instructors and classrooms within a school is called building the school schedule. For secondary schools, there are currently three types of scheduling used in American public schools: (1) class scheduling, in which each class group is scheduled together, and remains as a class group throughout all (or nearly all) school classes for the semester or year; (2) individual scheduling, in which each student follows a distinct schedule, and has a different set of classmates for each class; and (3) flexible scheduling, in which the school day is not arranged into periods of equal and fixed length, but into smaller modules, with a given class (say English literature) consisting of one or more contiguous modules, which may differ in length and position among different days of the weeks. Very few schools currently use flexible scheduling; there are many that use individual scheduling and many that use class scheduling.

At the elementary school, children in most schools have a single teacher for all or most of the day. Consequently, at elementary levels, scheduling is ordinarily done with relative ease.

Table 2

SUMMARY OF SURVEYED DATA SYSTEMS

	(1)	(2)	(3)
Name	Integrated Educational Information System (17)	Total Information Center (6)	Total Information for Educational Systems (7)
Area	MICHIGAN Counties of Macomb, Oakland, Wayne	OHIO Franklin County Columbus, Ohio	MINNESOTA Twin City Metro Area Seven Counties
School Population Serviced	1,150,000 (93 school districts)	92,230 (9 school districts)	126,000
Funding Source	TITLE III USOE ($607,000 over two-year period.)	TITLE III USOE $561,297 over three-year period. Participating schools charged per student as follows: elementary - $1.00, jr. high - $1.50, sr. high - $2.00)	TITLE III USOE ($983,376 over three-year period.)
Description	"An integrated educational information system will be set up to facilitate effective collection, storage, and retrieval of information with standardized formats....Systems will be developed for a computer-enriched curriculum, financial management, pupil personnel records, staff personnel records, and facilities and equipment...." (Reference 17, p. 1)	"To provide direct computer services in areas of curriculum, guidance, library services, and administration....The total information center will provide--(1) demonstration of the advantages of terminal connections to a centralized computer, (2) cost factors on the development of a regional processing center, (3) research and demonstration of the many uses of student records, and (4) cross files on vocational data, library holdings, and admission information for selected colleges and universities..." (Reference 6, p. 1)	"Data processing services... include (1) automatic generation of educational data required by the state department of education, (2) financial/administrative information, (3) student personnel information, (4) attendance and census information, (5) materials information in relation to library and audiovisual materials, and (6) instructional assistance in such areas as testing and curriculum development." (Reference 7, p. 1)

Table 2

(Continued)

	(4)	(5)	(6)
Name	Student Information System (1) Norwich Free Academy	California Total Education Information System (2)	NEEDS (8)
School Population	3,200	Potential / Actual Elementary 2,031,400 / 86,500 (4.2%) Secondary 1,066,529 / 308,600 (23.9%)	60,000 students 100 school systems; 6 state departments of education, colleges and universities
Funding Source	Internal funds	TITLE III funds with some support from county funds.	Ford Foundation
Description	Pupil personnel system including: 1. Scheduling, registration 2. Daily attendance 3. Class ranking 4. Grade reporting 5. Student activities 6. Permanent records maintenance	Overall system to be implemented incorporates administration, instructional administration and management science functions. Operational package for pupil personnel includes: 1. Scheduling 2. Mark reporting 3. Attendance accounting 4. Test scoring and reporting 5. Guidance counseling 6. Student record maintenance	Pupil personnel package includes: 1. Scheduling 2. Mark reporting 3. Attendance 4. Testing Overall purpose is to improve procedures in education to facilitate individualization of instruction.

Table 2

(Continued)

	(7)	(8)	(9)	(10)
Name	TIS (8)	UPDATE (8)	CPGA (8)	Broward County (8)
Area	Chicago Board of Education	Iowa	Unrestricted	Fort Lauderdale, Florida
School Population	--	--	--	81,000
Funding Source	--	Ford Foundation	Ford Foundation and Educational Testing Service	--
Description	System provides: 1. Budget and finance 2. Personnel and payroll 3. Materials 4. Student accounting and scheduling 5. Instruction in computer sciences. 6. Research	Designed to provide entire range of educational data. Concerned with what data to gather, how to collect it and how to effectively use it. Will continuously collect data throughout state of Iowa. Provide services. 1. Registering, scheduling 2. Assign lockers, auditor seats 3. Attendance 4. Report cards, enrollment projections	Approach to standardized way of presenting all important information that high school collects about its students. ETS releases computer programs and procedures to state education departments and universities wanting local use of CPGA.	System provides: Schedules, class rolls, locator cards, library labels, report cards, class loads, permanent record labels, GPA reports and grade distribution. Payroll and personnel, accounting, instruction, budget analysis, data transmission and system design.

The computer scheduling programs are designed to be used for individual scheduling, although some may be used also for flexible scheduling.

The construction of a schedule with the aid of a computer may be approached in several ways. A master schedule assigning rooms, teachers, subjects and times may first be built and then students may be scheduled within that framework. Or, the subjects, instructors, classrooms and students can simultaneously be considered in order to produce a school schedule in one process.

Making the school schedule is a tedious and time-consuming task. The school principal or other school administrator can easily spend at least one month and as many as six months in drawing up the schedule. To reduce the time involved, several computer programs have been developed to accomplish the sectioning or registering of students. Meanwhile, several attempts have been begun to computerize the entire scheduling procedure. In particular, work is being carried out at M.I.T. and Stanford in this area. Since the majority of schools surveyed built a master schedule first and then scheduled students within that framework, this is the organization presented in the discussion which follows.

1.1.1. Master Scheduling

The master schedule designates the time, room number and teacher for every course taught in the school. Drawing up the master schedule requires matching teacher, room, and time constraints. There have been attempts at entirely computerizing the formulation of the master schedule. Due to the large numbers of input parameters, direct solution of the problem is not likely. Instead the computer simulates the trial and error method of the human scheduler in arriving at possible teacher-room-time student assignments. Although usage of such programs is visible, the more widespread practice entails drawing up the master and student schedules separately. For most school districts using the computer in master scheduling, the computer provides guidelines for

the human scheduler and not the master schedule itself. In some instances, student course requests and maximum course size data are inputs to a program which then provides the number of sections needed for each course. A print-out of the number of requests by all pairs of courses is also printed. With this matrix it is possible to see that, for example, thirty students who want to take senior orchestra also want to take physics. Knowing this cross demand for courses can prevent many potential conflicts in construction of the master schedule. Using these guidelines, the human scheduler then makes out the master schedule. He writes the schedule onto a coding sheet for keypunching. Each punched card contains the name of the course, the time and place of meeting, the teacher's name and possibly any prerequisite courses. A computer program reads in the master schedule and, as one output, prints the schedule for each individual teacher. Then, if any teacher's schedule is too heavily concentrated in one part of the day, the master schedule can be adjusted in light of this fact. In summary, scheduling is still done by a person, with the computer providing useful guidelines in its formulation.

1.1.2. Student Scheduling

Student scheduling is the procedure which registers and schedules students for courses offered by the school. This procedure occurs at least once a year, and in school districts where course changes may take place at the second semester, it occurs twice a year. The inputs to student scheduling are the individual student course requests and the school's master schedule. From this process, each student receives a schedule, each teacher obtains class rosters, and the central office receives a master class schedule with names of students in each class.

Student scheduling entails matching student course requests with the offerings of the master schedule. In elementary schools where the students typically remain with the same teacher in the same classrooms for all courses, manual systems are widely used. In this case students are placed in homerooms and the schedule for all students in that room is the same.

At the high school level, many systems use either partially or totally automated systems for scheduling. In both cases the students receive either a mark sense card, or optical scan sheet, with their name and identification code marked on it. On this document, the student indicates his course requests for the next year. In one partially automated system that was examined, the procedures which were followed are these: The registration card is prepared by counselor and student. Meanwhile, class cards for available places in each course have been prepared (automatically from the master schedule) and placed in bins. To register a student in a particular course, a course card is removed from the requested course bin. Printing all the course cards and student's identification card provides the schedule for individual students. Printing all the request cards filed for the particular course provides the class roster.

Many systems use a partially automated system similar to the one described above. There has, however, been a proliferation of computer student scheduling programs in the past five years and many systems have tried them out. The satisfaction with the computer student scheduling appears high; in the four school districts we interviewed, only one was unhappy enough with the results to abandon this method completely. If a school district does not have its own computer, it either rents time commercially for scheduling or borrows time from some cooperating computer center.

To use a computer scheduling program, the student requests and the master schedule must be placed on machine readable documents. These are then input to the student scheduling program which produces a variety of outputs. Included are: (1) student conflicts, (2) individual student schedules, and (3) updated master schedule with the number of students assigned to each class.

Typically the first run produces conflict-free schedules for 90-95 percent of the students. The human scheduler must then rearrange the schedule to reduce these conflicts. Usually three iterations through the program produces a satisfactory schedule.

1.2. Attendance Reporting

Attendance reporting in secondary schools is ordinarily carried out by the homeroom teacher who transmits the names of absent students to the attendance officer. Master lists of absent students are then distributed to all teachers. Tallies of number of times absent are recorded on a student's report card and in his permanent folder. Monthly school-wide attendance reports are tallied for average daily attendance reports to the state.

In addition, there are readmission procedures to be followed after a student's absence. In a typical procedure, upon bringing a note from home explaining his absence, the student is readmitted to school. He then takes a readmission slip to every class, to be signed by the class teacher.

In one partially automated system that was surveyed, at the beginning of the year each homeroom teacher receives for each student expected in his home room an IBM card containing the student's name. When a student is absent, the homeroom teacher sends that student's card to data processing where a master absentee list is printed and distributed to teachers.

The virtue of using a completely automated system is the elimination of the hand recording of both the daily and other attendance reports. Daily attendance data for each student is automatically recorded in his master file and from these data attendance profiles, irregular attendance reports, average daily attendance reports may be generated.

1.3. Grade Reporting

Every teacher gives grades and records results of tests for each student in a gradebook. At certain intervals these grades are averaged and reports of each student's progress sent to his parents and recorded in his cumulative folder. Students may be ranked by their grade average; special lists such as honor roll, incompletes, or failures may be made; the distribution of grades given by each teacher may be provided.

In a manual system, each student's report card is circulated to all his teachers who record his grade for that class. This same grade

information is hand posted in the student's cumulative folder either by a homeroom teacher or a clerk.

Partially automated systems eliminate circulation of the grade reports among teachers. Instead, each teacher marks the grade on a machine-readable document, and returns these forms to the data processing center. A student's grade reports from his teachers are collated and his final report card is printed both on a report from for his parents and on a gummed label to affix to his cumulative folder.

In a completely automated system, the student answers his test questions on a form which the computer can read. Test scoring and recording of the grade are done by the computer which stores this information on tape or disk. From these data, averages are calculated by the computer, which periodically gives the teacher reports on student test averages. At report time, the teacher uses these reports from the computer to assign grades to students for that reporting period. The teacher reports grades on a machine-readable document as in the partially automated system. (It is possible also to have grade reports directly made by the computer from test averages, if the teacher prefers that the grade depend solely on these.) The report cards for distribution to parents are then generated. At the same time the student's master file on tape is updated with these current grades. Several special reports may optionally be available as part of the grade reporting process such as

(1) list of failures,
(2) list of honor roll students,
(3) list of students with incompletes, and
(4) rank of students by grade point average.

1.4. Standardized Testing

Some state governments require that a standardized testing program be carried out by each district in the state. Other states have a testing program that is voluntary for districts. In addition, most districts have their own standardized testing schedule, resulting in a large number of tests to be scored, recorded and analyzed. Appendix C contains the testing schedule for one of the school districts we interviewed.

A manual system for standardized test reporting requires a human grader to mark each item by comparing it with the scoring key. Scores are accumulated and then recorded for each student. School-wide averages, if obtained, would entail writing down and then summing all students' scores. Such manual procedures are highly tedious, and lead to frequent errors; they are seldom used by districts.

The procedures for collecting and maintaining standardized test data are very similar in the systems surveyed, which use partially automated systems. In this system, test packets containing the test and answer sheet are distributed to each student. These answer sheets have the student's name and identification code precoded on them. After test-taking, the tests are sent back to the test supplier for scoring and recording. The results are supplied as

(1) gummed labels with individual student scores,

(2) school averages, standard deviations, and

(3) district averages, standard deviations.

The virtue of a completely automated system for standardized test reporting is the accessibility of previous test reports so that over-time comparisons become possible. Tests are administered and scored in a manner similar to the semi-automated procedures. The results are stored electronically as well as in the cumulative folder, thus permitting the possibility of more easily retrieving and utilizing these data.

1.5. Career and College Counseling

Frequently the information on which students base their post-high school plans is obtained informally, in a non-systematic manner. The high school does provide career and college information, through such programs as "career nights" or "college days" in which representatives talk to the students. Additionally, job description pamphlets and college catalogues are available for the students. In many schools, post-college plans are discussed with counselors or in home rooms throughout college careers.

Counseling the student about his post-high school plans often uses aptitude and interest tests. The scoring and recording of these

tests is similar to the procedure for standardized achievement test reporting.

Currently, there are several projects underway which are utilizing computer assistance in counseling. A central feature of these systems is a computer library or data base of career and college information along with methods for its retrieval. One career guidance system asks the student about his interests and post-high school plans and then lists possible jobs matching his characteristics. Then the student may request additional information about any of these jobs.

The College Entrance Examination Board is developing one such system, called the College Locator Service, to give students information on which to base their selection of a college.

Currently the student has very little data on which to decide which college to attend. He may read what the college chooses to tell him in its catalogue, or he may talk to students attending that college. On the other hand, the colleges gain quite detailed information about applicants from their high school records and College Entrance Examination Board tests. A college locator service by providing substantive information about the college's performance, would help redress this imbalance of information between the colleges and their applicants.

1.6. Master File Maintenance

The depository for the output of all these procedures is the student master history file, called his cumulative record. Typically this record is a manila folder with space allocated for recording grades, standardized scores and background information of the student. State law may require that such a folder be kept and specify the minimum contents of this folder. Appendix B contains the California state law requirements and an actual sample folder for a student at the end of high school.

Most school districts store this master file as a physical record and manually update their students' master records. Thus attendance data, names, and grades earned in courses are all manually transcribed into the student's record. Some automation of the preparation of data to be inserted in the record has been carried out. For instance, test

Table 3

PUPIL PERSONNEL ADMINISTRATIVE ACTIVITIES CARRIED OUT BY SCHOOLS

	1	2
ACTIVITY	MASTER SCHEDULING	STUDENT SCHEDULING
INPUTS	1. Teacher resources 2. Available rooms 3. Student course requests	1. Master schedule 2. Student course requests
OUTPUTS	Master schedule with teacher, time, course, and room assignments	1. Class rosters by teacher 2. Individual student requests 3. Master class schedule
PROCEDURE	1. <u>Manual system</u> 2. <u>Partially automated system</u> Computer or tab equipment produces tallies of student course requests, potential course conflicts, teacher-loading which may be used as guides to human scheduler.	1. <u>Manual system</u> 2. <u>Partially automated system</u> Computer or tab equipment produces cards for each class section. Counselors schedule students and register students by pulling class card from bin or file. Student cards printed to produce schedule. 3. <u>Automated system</u> Student indicates course request on machine readable document. Course requests and master schedule are input to computer scheduling program which indicates conflicts (if any) and prints student schedule.
PERSONS INVOLVED IN PREPARATION	Administrative school personnel Assistant principal	Student, counselor, data processing
FREQUENCY	Once or twice yearly	Once or twice yearly

Table 3

(Continued)

ACTIVITY	3 ATTENDANCE REPORTING	4 GRADE REPORTING
INPUTS	1. Class roster 2. Absent students	1. Class roster 2. Student grade
OUTPUTS	1. Recording students' absence in teachers' records 2. Recording students' absence in central office 3. Master list of absent students	1. Report of students' progress at various time intervals 2. Ranking of students by grades 3. Distribution of grades by teacher 4. Special lists (honor rolls, failures, incompletes)
PROCEDURE	1. <u>Manual system</u> Teacher sends absence slip to office where master list hand-posted. Teacher records absences in gradebook. 2. <u>Partially automated system</u> At beginning of semester teacher receives pack of IBM cards containing one card for each student in class. If a student is absent, his card is sent to data processing where master list o. absentees is printed. Teacher records absence in gradebook. 3. <u>Automated system</u> Teacher records absence on some machine-readable form, student's file is updated accordingly, tallies and absentee lists are printed.	1. <u>Manual system</u> Teacher records grades, averages them and hand-posts final grades on report cards, cumulative folder and grade-book. 2. <u>Partially automated system</u> Teacher marks grade on machine-readable document, tab or computer reads and prints report cards, gummed labels. Labels affixed to cumulative folder. 3. <u>Automated system</u> Students record test answers on machine-readable document, computer scores, records and averages grades, prints report cards and up-dates student cumulative history file. Ranking, dis-tribution of grades and any special reports are produced at time of update.
PERSONS INVOLVED IN PREPA-RATION	Teacher, attendance officer, student	Teacher, data processing
FREQUENCY	Daily	Periodic within semester

Table 3

(Continued)

	5	6
ACTIVITY	STANDARDIZED TESTING	CAREER AND COLLEGE GUIDANCE
INPUTS	1. Names of all students in schools 2. Test packets	1. Student master file 2. Career and college information 3. Interest and aptitude tests 4. Student guidance requests
OUTPUTS	1. Forms for test answers 2. Scoring of test 3. Recording results of tests of individual students 4. Aggregating test scores at school level 5. Evaluations	1. Test results 2. Guidance information
PROCEDURE	1. <u>Manual system</u> Tests scored, recorded and analyzed by hand. 2. <u>Partially automated system</u> Students record answers on machine-readable document, computer scores, records tests, for individual, aggregates individual scores for school averages. Individual records updated by affixing gummed labels. 3. <u>Automated system</u> Test scoring, reporting done by computer. Student cumulative file updated with current test score. Achievement change since previous test is charted.	1. <u>Manual system</u> 2. <u>Partially automated system</u> Students record answers to interest and aptitude tests on machine-readable document. Computer scores, records test results. 3. <u>Automated system</u> Computer "data base" of job and college information along with methods for retrieval are made available to student. The computer may ask student about his interests and post-high school plans, then list jobs or colleges fitting these categories. Following this, student requests additional information about any of these jobs.
PERSONS INVOLVED IN PREPARATION	Teacher, data processing	Counselor, teacher
FREQUENCY	Once a year	Variable

Table 3

(Continued)

7

ACTIVITY	MASTER FILE MAINTENANCE
INPUTS	1. Initial file data 2. Student master file 3. Updates
OUTPUTS	1. New master file 2. Reports from master file 3. Selected student records
PROCEDURE	1. <u>Manual system</u> Students cumulative folder is updated manually. 2. <u>Partially automated system</u> Updates are prepared on tab or computer, but are hand-posted in cumulative folder. 3. <u>Automated system</u> Updates are prepared on computer and master file is updated by computer.
PERSONS INVOLVED IN PREPARATION	Teacher, counselor, clerical staff, data processing
FREQUENCY	Approximately twenty times/year

scores are printed by a computer on gummed labels instead of being handwritten. But these same test scores still must be affixed to the cumulative record, a manual process.

There are a few examples of master records stored electronically, either on magnetic tape or disk. When the student's master file is stored in this manner, updating his file becomes a part of the report generation process. Manual transcription of the results of an activity (e.g. grade reporting, standardized testing) to the master file is eliminated, since the master record is automatically updated when the results of the activity are recorded. With a fully automated data system, information is added to the student's folder as it becomes available, not at the end of the year or some other arbitrary update time. Thus the student's folder always contains current information, and accurately reflects the current status of the student. The cumulative file, which in most schools at present is the depository of historical information about the student, has the possibility of becoming the data base for continual monitoring of a student's progress.

One school district surveyed had placed the most recent seven semesters of each student's cumulative record on a magnetic tape. Computer programs were written to scan the tape for persons fitting particular characteristics -- for instance, location of all those junior year students who had not completed the health course requirement -- and the list of persons satisfying this characteristic would be printed. The district had not developed a general information retrieval system, but wrote a new program to search for each specific characteristic.

2. Modes of Computer access

Nearly all the computer systems that currently exist in schools operate with a central computer, located at a district or regional office (or in rare cases, at a high school), to which jobs are submitted, inserted in a schedule, and then run in scheduled sequence. However, recent developments have allowed new modes of computer access, and it is useful to examine briefly the differences in mode of operation this can allow.

It is useful to examine the various modes of access to a computer according to two dimensions: access may be either interactive or non-interactive, and it may involve simultaneous access by more than one user or exclusive access by a single user. Table 4 classifies computer systems by these two dimensions.

Table 4
MODES OF COMPUTER ACCESS

	Non-interactive	Interactive
Simultaneous access by more than one user	Multi-programming remote batch	Time-sharing
Access by one user	Batch processing	Dedicated system

Non-interactive access means that the computer user and the computer do not have any two-way communication during the execution of the user's program. The computer may print various data during execution, but the user has no way to interact with the computer at the time of execution. Usually, none of the results of program execution are seen until after the completion of execution.

On the other hand, in an interactive access system, the user and program may have a great deal of communication during the execution of the program. Such systems permit the user to monitor his program during execution. In addition, the program may include points at which he enters new data. For example, the user may enter a set of students' grades in response to a computer request, and the computer immediately adds these grades to prior grades and prints out the new grade averages to the user. The important distinction between interactive and non-interactive systems is the two-way communication that can occur during program execution in interactive systems.

The other variable used in classifying modes of computer access is the number of users who have access at any one time.

In many computer systems, access to the computer is limited to one user at a time. The computer belongs exclusively to this one user during the execution of his program; other programs do not interrupt its execution. In a non-interactive, one-user system or batch processing system, users typically submit programs to a central computing facility. These jobs are run on the computer in an order established by a computer job scheduler. The turnaround time (time between job submittal and job completion) may be minutes, hours, or longer, but is ordinarily measured in hours, and sometimes in days.

A one-user system can be interactive, as a dedicated system. For instance, while a program is in execution, the computer operator can display registers and alter contents of the computer.

Simultaneity of access refers to systems in which execution of one program is interspersed with the execution of one or more other programs. The computer jumps from program to program, not performing execution of one entire program as a unit, but executing portions of many programs -- either to allow interactive capability to a number of users as in time sharing, or to allow more efficient use of different computer components, as in multi-programming. Although multiple user access to the computer may be generally called time-sharing, the term "time-sharing" has come to mean a time-shared computer with interactive remote users. These definitions will be used in the discussion which follows.

multiprogramming -- non-remote, non-interactive time sharing
time-sharing system -- remote, interactive time-sharing
remote batch -- remote, non-interactive, non-time-sharing, or time-sharing

In multi-programming systems, the users do not interact with their program during its execution. Programs are submitted to a central computing facility where they are run and then retrieved by the user. Swapping of execution of programs is done to maximize machine efficiency.

Time-sharing systems are on the other hand interactive. The user through the use of a teletypewriter or equivalent device has the computer at his fingertips and may enter programs, compile them, edit them, enter data, and receive output data. There is a central computer to which the remote users are attached via phone lines and teletypewriters.

The user "calls" the computer and then begins entering his program or data on the teletypewriter.

Remote batch users are linked to the computer via phone lines as well. In this mode the remote user requests that a job be run at some later time. The output may be returned to him via messenger, or through his remote terminal, depending on the amount of output and the capability of his terminal. He does not interact with the program during its execution.

Until recently, computers were restricted to access by one user. Even now, most computer installations operate in this mode. However, recent developments in computers and systems programming have made possible simultaneous access by many users, and with appropriate systems programming, an interactive mode. A number of commercial services now offer time-sharing and remote batch operation via telephone lines, with the remote user having a teletypewriter or card reader input, and teletypewriter or line printer output.

A remote station with card reader input, printer output, interactive capability through a typewriter, and magnetic tape and disk file storage at the central computer has effectively the essential capabilities of the central computer directly accessible to him in time and space. Perhaps equally important, he has capital expenditures only for his terminal equipment, and pays computer cost through user charges.

3. HISTORIES OF THREE PROJECTS

3.1. California Total Education Information System (2, 3, 4)

The State Pilot Project in Education, carried out by the Richmond City Schools under NDEA Title V grant in 1960-1963, was the first phase of a broad state program aimed at providing integrated data processing in the state of California. It was principally a feasibility study involving field testing of a pupil personnel package in five school districts. The conclusions drawn were that "many districts, many schools, and many educators can get together and work out a

successful data processing system. They can develop applications that are not only feasible and workable but really efficient. . ." (4, p. 139).

The second phase called for establishment of two Regional Centers in Sacramento and Ventura, which were funded by the USOE. These centers were organized to develop prototypes of computer programs for use at regional data processing centers to be established later. By the completion of the project in June 1965, packages for scheduling, mark reporting, attendance reporting, test scoring and reporting, and guidance counseling services were operational.

Using the promising results of these two centers as guides, eight additional centers were funded in 1965 by the State Department of Education and by a USOE Title III grant. In 1968 nine of the original ten plus three new centers were in operation. These centers are located in Ventura, Sacramento, Fresno, Kern, San Mateo, Contra Costa, Sonoma, San Francisco, Santa Clara, Riverside, San Diego and Los Angeles (3, p. 8).

The passage of Assembly Bill 1610 (10) in 1968 provided for the establishment of the California Educational Information System within the Department of Education. The bill does not specifically state that the regional centers will be responsible for the execution of the system. Presumably, they are the intended places for execution of such a project.

Currently the only operational package at the regional centers is the pupil personnel package. The projected date for operation of the business package is late 1969 (for further information, see reference 5).

FEATURES OF THE PUPIL PERSONNEL SYSTEM

Six functions of this system are described briefly below:

3.1.1. Scheduling

The master schedule is prepared by a human scheduler with tallies of student course request providing him rough guidelines. From these parameters and from teacher and room constraints, a master schedule is prepared. The student requests and master schedule are inputs to the scheduling program which attempts to schedule all students with the

minimum number of conflicts. The conflict list is printed and the human scheduler must adjust the schedule in light of these problems. Usually three passes through the program are needed to reduce the conflicts to acceptable proportion. Finally, class rosters and individual student schedules are printed.

3.1.2. Attendance Accounting

Schools maintain attendance reports on preprinted forms and send these to the regional centers. From these forms individual student attendance reports are generated and an analysis of irregular attendance records is made.

3.1.3. Grade Reporting

Teachers record their students' grades and comments about performance by checking a preassigned numeric code on a preprinted machine readable form. Grade reports are generated and distributed to (1) parents, and (2) (in the form of gummed labels) the students' cumulative folders. A variety of statistics are produced from these grades, including distribution of marks for each class and teacher, and a listing of students receiving failures and incompletes.

3.1.4. Standardized Test Reporting

There are four phases to the test reporting section.

(1) Preparation of test packet. Each student's name is prepunched into his test answer cards and these cards are assembled with testing materials.

(2) Scoring of tests.

(3) Recording and distributing test scores.

(4) Printing state-required tests results by district.

3.1.5. Guidance Counseling

A record may be produced for each student containing a summary of courses, standardized test scores, grades, and earned credit. This function is not available from all centers.

3.1.6. Master File Maintenance

This function creates and updates the student master file, consequently it receives and transmits data from all parts of the system -- scheduling, attendance accounting, mark reporting, test reporting, and guidance. A description of the contents of the school student master file is given in Appendix A.

EQUIPMENT AT CENTERS

Type of Equipment	Number Installed
Honeywell 200	4
Honeywell 2200	1
IBM 360/30	2
IBM 360/40	2

Funding Arrangements

Most of the centers were begun with Title III funds. At least three of the centers are heavily supported by county funds.

Approximate Cost Per Pupil

The range of prices charged by the regional centers to local districts for the pupil personnel package is given in the table below (reference 3, Table 7, page A-9).

Secondary		Elementary	
1967-68	1968-69	1967-68	1968-69
\$2.50-4.00	\$2.90-4.67	\$1.00-1.50	\$1.25-1.75

These differences in prices are due somewhat to different services -- for instance, some centers did not offer the guidance counseling package (function 6). The purpose in presenting these numbers is to give a range of prices charged for the pupil personnel functions.

The prices, however, reflect only a portion of costs. The San Diego Regional Center, for example, which charged a price of \$3.00 per

pupil at the secondary level in 1967-68 reports 19,000 pupils served with an "approximate expenditure for pupil personnel services" of $159,000, or $8.37 per pupil (reference 3, Tables 3 and 4, pages A-5, A-6). Even these costs must be treated with caution. A center's estimates of expenditures did not include the subsidies in the form of free services or rent-free facilities from county. Centers did not keep detailed cost records by type of service provided, therefore the proportion of expenses accountable to pupil personnel is only estimated. It is also not clear just how fully regional centers are used by those districts which participate in services, and pay for the pupil personnel package. Some of the services are at the option of the teacher, counselor, or school, and use may vary widely in a district. None of the four districts visited in the Los Angeles area mentioned use of the Regional Center, though some are counted by the Center as users.

3.2. Area Education Information Center
Franklin County Schools, Ohio (5, 6)

For several years, the Franklin County Educational Data Processing Center provided pupil personnel services to 30,000 pupils using unit record equipment. The price charged for these services was $1 per elementary student, $1.50 per junior high student, and $2 per secondary student. To meet demands for service from an increasing population, the unit record equipment was replaced by a computer. (No detailed information was available on the configuration.) The support for this installation came originally from Title III funds from the U.S.O.E.

FEATURES OF PUPIL PERSONNEL SYSTEM

3.2.1. Scheduling

Each school receives student course election cards on which every student prints his course requests. These requests are then keypunched and run through a program which produces the number of requests for each course and a course conflict matrix giving the number of potential conflicts between courses. From these two outputs the human scheduler

has good guidelines for making up the master schedule. After drawing up a proposed master schedule, it is keypunched and goes into the scheduling program along with the student election cards. Several runs through the program are usually needed to obtain a usable schedule. Among the reports generated are course master listings, conflict reports, room, teacher and period load, and master list by period. Based on these reports the scheduler may want to juggle the schedule in certain directions. The final run produces student schedules, class rosters, homeroom rosters, study hall input list and study hall rosters.

This scheduling procedure for a given year usually begins at the start of the second semester of the preceding year.

3.2.2. Attendance Reporting

Daily attendance is kept by the individual teachers in their gradebooks; only aggregated attendance records are recorded on optical scan sheets for processing by the computer. The attendance report presents the number of days present and absent for each student and the totals for the entire school. These data are saved on an attendance data tape and later used when printing the student's grade report.

3.2.3. Grade Reporting

Teachers turn in their students' grades on optical mark sheets. Reports generated from these sheets include

(1) grade reports (with numeric or alphabetic grades),
(2) list of failures,
(3) grade distribution by teacher,
(4) incomplete listing,
(5) ranking of students by grade point average, and
(6) gummed labels for affixing to cumulative folder.

3.2.4. Standardized Test Reporting

No information was available about this procedure.

Funding Arrangements

This project was initially funded by Title III USOE grant with local support from participating schools. Price to participating districts is as follows:

A one-time charge for all new schools for preparation of of master data cards.	\$ .25 per student
Elementary Package.	\$1.00 per student
Grade and attendance reporting	
Six weeks or nine weeks attendance report	
Junior High Package.	\$1.50 per student
Grade and attendance reporting including:	
Six weeks attendance report	
Failure list	
Incomplete list	
Point average and class rank	
Teacher grade distribution report	
Scheduling (optional) additional charge:	\$ .50 per student
Senior High Package.	
Total package	\$2.00 per student

3.3. Norwich Free Academy (1)

Norwich, Connecticut

FEATURES OF PUPIL PERSONNEL SYSTEM

An IBM 1401 with disk storage is used to provide pupil personnel services. The various components are described below.

3.3.1. Scheduling

Course catalogues are distributed to students along with program cards for recording of course choices. These cards have the student's name and identification prepunched. The students write down the course number and title and return these cards for keypunching. The punched program cards provide preliminary course count and section data for use in formulating the master schedule.

The previous year's master schedule is stored on disk and is analyzed for teacher load and other paremeters. Modifications on the basis of these outputs and the new student requests are made. Usually 75-80 percent of the previous year's master schedule can be used again.

Student scheduling or sectioning is done by matching the student course requests against the master schedule. Class lists, student schedules, class seat counts are printed as part of the scheduling program.

3.3.2. Daily Attendance

Each homeroom teacher receives a punched card for all students in the homeroom. A student's absence is recorded by removing his card from this file and sending it to data processing center. From these cards the 1401 prints a daily attendance report, produces a punched card which notifies the parents of their child's absence. This card is signed by the parent and used to readmit the student to classes.

3.3.3. Grade Reporting

Cards with student's name and course identification are prepared for each class. These cards contain prescored positions which correspond to actual grades to be given. Using a stylus, the teacher punches out the appropriate mark. Class ranking, honor rolls are printed as part of the grade reporting procedure.

3.3.4. Standardized Testing

This function is currently not aided by the computer.

3.3.5. Master File Maintenance

Apparently the student's cumulative record is not maintained on magnetic tape, but is kept in a physical record.

Approximate Cost Per Pupil

No information was available on the cost of this system. Rough estimates could be made by knowing the cost of the 1401 system. This system together with supporting equipment, costs about $50,000 per year after an educational discount. Supporting personnel costs are probably about $20,000 per year. Thus hardware and personnel costs are in the

neighborhood of $70,000, or about $20 per pupil per year for a student population of 3200. The computer, however, is used for other purposes, including student instruction in computer use, so that not all costs should be allocated to this purpose.

4. CURRICULAR-RELATED SYSTEMS

The systems described thus far may be called administrative-related systems since their purpose basically is to provide for smoother operation of administrative functions. In a few instances, data systems are being developed which are related to other functions. One example is Westinghouse Corporation's PLAN, a curricular-related system. The goals of this project are the provision of instruction on an individualized basis by providing a constant monitoring and feedback of the student's progress. A computer is used to do the planning, organizing, and recording of the student's progress. The curriculum is subdivided into units with specific learning objectives. When a student thinks he has mastered the material he takes a test and upon achieving a satisfactory score on it may proceed to the next learning unit. The testing of the student, and a list of what materials are next appropriate for him to use are provided by the computer program.

III. THE DESIGN OF INFORMATION SYSTEMS FOR MULTI-LEVEL DECISIONS

Information systems for educational decisions can build upon the data systems currently being implemented in schools when the systems are appropriately designed. The problems in design involve several points:

1. Technical problems arising from differences between the locus at which data are generated, the locus at which the file is maintained, and the locus at which information is needed for decisions.

2. Problems of control of and access to the information.

3. Problems of compatibility of data from different schools or different school districts.

4. Problems of missing information: data not ordinarily obtained or filed for administration purposes, but necessary for decisions of various types.

5. Problems of information aggregation, analysis, and presentation.

This section will examine each of these problems and outline the requirements of a system which will provide information at multiple levels for educational decisions.

1. THE LOCI AT WHICH DATA ARE GENERATED AND FILES ARE MAINTAINED

Section II examined the various activities involved in generation and maintenance of student information. In general, these data are generated at either the classroom level or at the school level, and files are maintained at the school level. In some cases, individual student records are maintained at the district level, containing selected information from the student record maintained at the school. The automation of student record maintenance will make this pattern more frequent in the future, where computer hardware exists only at the district level. This student information, maintained at the school or district level, is in unaggregated form. Thus, to refer to Table 1 on p. 4, it contains information of type 7 and sometimes 1, useful only for decisions about particular students independent of educational environment, and sometimes in particular environments (e.g., how well a student is doing in a given track).

Student performance data are also maintained in aggregated form at higher levels (district, state), giving information of types 3 and 9 in Table 1. However, so long as these data are not associated with information about the educational environments, they do not provide information of types 4, 5, and 6, which is probably the type of information most broadly needed for decisions, as indicated in Section I.

Certain data on student performance are generated at higher levels. Machine-scored tests are ordinarily scored at a district level or higher (and sometimes by an outside service contractor). Information on post-school activities, in education or in occupations, is generated outside the school system, either in college or places of work. Because such data are not generated within the school system, they ordinarily do not enter educational records, even though they constitute valuable information to the school concerning the performance of its products, and thus indirectly its own performance.

In addition to student performance information, other information is necessary for educational decisions. In Section I, a second kind of information was discussed: information on the educational environments to which the student is exposed. Probably the most important aspect of the environment, in the current organization of schools, is the teacher. Information on teachers is ordinarily maintained in files that are wholly unassociated with student-performance files. Most data on teachers is maintained at the district level, where hiring occurs, rather than at the school level. Only the teacher performance data subsequent to hiring are regularly maintained at the school level -- and such performance data are ordinarily of little use, recorded only during an initial probationary period and based on vague criteria, subjective judgments, and inadequate observation.

In many school districts, however, objective data on teachers is obtained at the time of hiring, through the employment application form and standardized teacher examinations. Such data constitute reasonably good measures of aspects of the environment to which students of that teacher are exposed, and with appropriate linking of data at different levels, can be used for such a purpose, providing information of types 4, 5, and 6 in Table 1 on page 4.

Data on other aspects of the educational environment of a child, such as the curriculum and textbooks to which he is exposed, the size of classes, school equipment and facilities, and expenditure information, is generated at either the school or district level, and maintained at the district and state levels. Information required by state departments of education (principally expenditures, but also aggregate measures of other items, such as average class size, teacher preparation, and various equipment) are maintained well; information not required by the state is less well-maintained. All such information is maintained fully separate from student records containing student performance data. Consequently, explicit linkages of these data to student performance data is necessary if the information is to be useful for educational decisions. When such linkage is made, the information that can be generated is of types 4, 5, and 6 in Table 1.

An overall tabulation of types of data generated and maintained relevant to educational decisions is given in Table 5. The rows of the table show types of data that are generated, and the columns show the locus which is the source of the data, and the locus at which files are maintained in unaggregated form. The letter "S" is used to indicate the locus at which the data originate, and the letter "M" is used to indicate the locus at which the data are maintained in unaggregated form. Subscripts are added when the data may originate or be maintained at more than one locus; and parentheses in three cases around "M" indicate that such maintenance sometimes occurs, but is rare. The right-hand column of the table shows the adequacy with which files are maintained for each type of data, with 0 indicating no maintenance, and 1 indicating fully adequate maintenance. The estimates are very rough, and give a combined indication of the frequency with which such files are maintained, and the quality of the data.

The table shows where problems arise at this stage: when data files are maintained at different locations than those at which the data are generated. This involves a physical transfer from one location to another: from the classroom to the school's administrative office; from the school's administrative office to the district administrative office; from the district administrative office to the state department

TABLE 5

Generation and maintenance of data necessary for educational decisions related to student performance.

	Locus of data source (S) and file maintenance (M)					
	Homeroom or Classroom	School	District	State or Federal	College	Adequacy of File Maintenance
Student Data						
Background	S	M_1	(M_2)			0.6
Course Schedule		S, M				1.0
Semester Grades	S	M_1	(M_2)			1.0
Within-Semester Grades	S					0.0
Attendance	S	M				1.0
Standard Test Scores		M_1	S, (M_2)			1.0
Extra-curricular	S	M				0.5
Secondary School Performance (Elementary)		S, M				0.1
College Application (Secondary)		S, M				0.5
College Admission (Secondary)					S	0.1
College History (Secondary)					S	0.1
Work History (Secondary)				S		0.0
Teacher Data						
Background, preparation			S, M			0.8
Application Test Score			S, M			0.5
Course Schedule		S, M				0.5
Performance Ratings		S, M	M_2			0.5
Salaries			S, M			1.0
Program Data						
Textbooks, Curriculum		S_1	S_2	S_3		0.0
Pupil-Teacher Ratio or Class Size		S	M			0.8
Library and Other Equip.		S_1, M_1	S_2, M_2			0.8
Current and Capital Expenditures			S, M			1.0

of education; ˙-om the state department to the United States Office of Education. The transfers from one location to another are most routine when they are upward along an organizational line of authority, within the school district. They become more problematic when they are upward to a higher level of government, but this becomes rather routine when the higher level of government makes funds conditional upon receipt of the information, as do state education departments. Where the transfers become most problematic, however, is along a path that is neither of these. As a simple example, elementary schools very seldom receive information on their students in secondary schools, even when the secondary schools are part of the same school district. Such an information flow requires either transfer of information up from the secondary schools to the district office, and then back down to the elementary school from the district, or else across organizational lines, directly from secondary schools to the elementary school. Other examples of problematic transfers are data flows from colleges or places of employment to high schools (except for the original application to colleges, for which the high school must send transcripts). Such information is important for examining the longer range performance of students, and thus through analysis the effect of the school upon him. Yet such data are rarely obtained, except for special projects in which the school follows a particular year's graduates for a short period of time. These transfers of data in directions other than upward along authority lines are rare, sometimes because they are technically more difficult, but also because there is not sufficient organizational incentive for them. There is, however, a balance between incentive and technical difficulties: if the incentive is present but weak, a reduction of technical difficulties can greatly increase the data flow.

It is in this context that a recent development in technology is especially relevant. Probably the most important development in computer technology in the past several years is direct access to remote, electronically stored files by multiple users. This development, which involves the use of time-shared systems and remote input-output equipment, has been described above, in Section II. Such a system is ideally suited to dispersed data-origination and data-use described in

Table 5, and implied by any multi-level information system, for it eliminates the need for physical transfer of data from one location to another. Indeed, it is only the existence and economic feasibility of such remote access systems that make possible a multi-level information system of the sort under consideration here. Typical "management information systems" provide only for upward flow of information along organizational authority lines, and access to information dictated by such lines, ordinarily single access at the top, where the "decision-maker" is to be found. Such a conception of decision-making is compatible with the central, single-access computer. In educational systems, decision-makers should be located at many points in and outside the formal organization. For such decision structures, remote-access, multiple-user computer systems provide the appropriate technology.

2. CONTROL OF DATA FILES AND ACCESS TO THEM

The commercial availability of electronic files with remote accessibility at prices that make them economically feasible provides a technical solution to data transfer for multi-level information systems. The problems of control of files and access to them are problems of a different sort. In an hierarchical authority system, the problem is resolved by lines of authority: information is accessible from above, along lines of authority, and only under special conditions accessible from below or across authority jurisdictions. However, in the emerging structure of public education, individual citizens, state departments of education, state and federal legislatures, and federal agencies, none of which are within the organizational hierarchy, are exercising claims for rights of access to educational information; and since public education is ultimately responsible to the public, many of these claims have the weight of legitimacy. It is far from certain what rules of access will ultimately emerge as technical feasibility increases the urgency of such explicit rules; but two patterns appear as possible alternatives, only one of which is fully compatible with the multi-level decision system under consideration here. This is the concept of a disinterested party, outside the educational system and bonded to insure accountability, acting as an information-banker.

The Concept of an Educational Information Banker

If an information system of the sort discussed in this memorandum is to be implemented, it implies a role which is new in education, and perhaps in society generally. None of the interested parties who must make educational decisions, from the federal government down to the family, has a right of access to all information files; yet all parties have need of information created at other levels by other interested parties. Thus no one of the interested parties can legitimately be the repository for the information necessary to each party. Most of the information is generated either at the level of the school or at the level of the classroom; but even the parties at these levels, principals and teachers, need information from other schools and other classrooms for the decisions they must make. Thus quite apart from the needs of other parties for the information currently maintained at the school level, those within the school need a broader information base for many of their decisions,

Thus a role of "information-banker" is necessary in order to receive information from various input sources and make available to each party the information to which it has legitimate access, after appropriate aggregation and analysis. Such an information-banker must have a number of functions if it is to carry out such a role adequately. These functions are very similar to those of a money-banker, although certain initial design functions, (a) and (b) below, are necessitated by the fact that such a role is a new one. The necessary functions are:

(a) Create the design for an information system which receives information from various sources, processes the information in appropriate ways, and provides output information to interested parties.

(b) Assist in the design of any satellite data systems, as in individual school districts or even schools, to insure compatibility with, and automatic inputs to, the information bank.

(c) Monitor inputs to the information-bank from each source, to insure quality and quantity of information.

(d) Maintain necessary information bank or files, with security against illegitimate access.

(e) Provide to each of the interested parties that information to which it has legitimate access, after processing to make it relevant to the decisions of that party.

This role will necessarily evolve in some ways that cannot be presently foreseen; what is important is the basic concept of the role: a disinterested party, who receives input data from sources at which it is generated, protects this information from illegitimate access, processes it and makes it available in useful form to aid decisions of various parties. There will undoubtedly emerge institutional safeguards to such a service just as in the use of banking: bonded employees, insurance against violations of security, and similar mechanisms. However, the conflicts of interest and security problems are not the most critical ones in development of this role; most of the information is not of interest to those parties who will not have legitimate access to it. The most critical problems are the technical ones of development of appropriate procedures for assuring input, analysis, and presentation of information so that it is available and useful for educational decisions.

The second possible pattern for information systems in education is a steady movement toward centralization of information, first at the school district level, then at the state and possibly federal levels. Sophisticated data systems, with large capital expenditures for computer equipment, cannot be designed and maintained at the school level, nor at the level of the small district. In addition, the demand of higher levels (state and federal) for performance, program, and expenditure information to aid their decisions exerts a continuing pressure for centralization of file maintenance.

The consequence of such a drift toward centralization of information is a steady erosion of power at lower levels within the educational system: the teacher relative to the principal, then the principal relative to the district superintendent, then the district superintendent relative to the state superintendent, and finally the state superintendent relative to the United States Office of Education. The resentment of each level toward the increasing demands of the next

higher level for information is already apparent: the state education departments toward U.S.O.E., the districts toward the state, the principals toward the districts, and the teachers toward the principal.

Despite this resentment, it is the new demands of those outside the educational hierarchy for information about performance -- parents, state legislatures, Congress -- which makes the emergence of the new role of information-banker an especially likely one. For there are no grounds within a bureaucratic organization for legitimacy of access to information except upward along the lines of authority. In contrast, those outside a public bureaucracy who individually constitute its involuntary clients can demand certain information that directly affects them (such as performance information concerning their child); and those same persons, collectively constituting the owners of the public bureaucracy can, with even stronger claims to legitimacy, demand more general information about the performance of the organization, through their organs of representative government. It is through these channels, that is, through legislation, that the rules governing availability, access, and control of information, and the role-definition of information-banker should emerge. Legislative committee is probably the most appropriate arena for the interests of various parties to shape the rules under which such a system should operate.

<u>A note on security procedures in time-shared systems</u>: One of the major problems that must be solved in any computer system with multiple access to a set of files (a characteristic of all time-sharing systems) is that of file security, restricting access to a specified set of users. Commercial time-sharing firms have developed rather elaborate security systems, for some of their users file information that could be of great interest to other users. These security systems take either of two general forms: systems which restrict file access to a particular set of terminal devices, which have identifying codes built into the hardware; and systems which restrict file access to a particular set of persons, independent of the terminal device, who may unlock the file through use of a particular code word, entered into the input device. The first is comparable to a physical lock opened with a key; the second is comparable to a physical lock opened with a

combination. For physical files, neither of these devices is fully satisfactory; but they are the best means devised for security. The procedures for file security in computers, at the present stage of development, seem no worse and no better (except that access cannot be obtained purely through physical force, as in dynamiting a safe) than the methods for physical file security. They are not perfect, but no security system is, and they carry no unique hazards not shared by physical file systems.

3. COMPARABILITY OF DATA FROM DIFFERENT SCHOOLS AND SCHOOL DISTRICTS.

Many of the fruits of an information system of the sort under consideration here cannot be realized within the confines of a given school district. Yet at present, it is only within the confines of a district that data comparability is maintained, because each district is a distinct administrative unit. Because of the pressure toward information-flow upward to the state level, increasing comparability is being developed among districts in a state. This is part of the general pressure toward centralization described in the preceding section, and will result in increasing information-access from above, but not down, across, or outside the organization.

Yet if teachers, principals, district superintendents, and parents are to be able to use such an information system to aid decisions, data from a number of classrooms, schools, and districts must be brought to bear on the decisions. As was indicated in Section I, each of these parties makes decisions involving the second row of Table 1, cells 4, 5, or 6. This row of the table uses information about characteristics of educational environments in relation to student performance. By its very nature, such analysis requires information from many different environments, and not a particular environment, as in row 1 of the table. At the lowest level, information is necessary from many classrooms, to enable abstraction of characteristics of the classroom environment, and relate those characteristics to student performance in these classrooms; from different schools, to relate school characteristics to performance; and from different districts, to relate characteristics of programs and curricula that differ only between districts to

performance. Information most important to the party at a given level is information concerning that level across environments with different characteristics. The teacher needs information about effects of class activity characteristics which may differ from her own; the principal needs information about effects of school characteristics; and the district superintendent needs information about effects of program characteristics that differ only between districts.

To establish such comparability requires an information system that transcends districts, such as that implied by the information-banker concept discussed above, or by the regional data systems in California, discussed in Section II. The technical and organizational problems of developing such data comparability are not unique to the system under consideration; their resolution will follow upon the establishment of an organizational framework by which a multi-level information system is to be implemented.

4. MISSING INFORMATION

The data which are best maintained in schools are data on student performance. But an information system appropriate to educational decisions requires merging performance data with educational environment data. Data on educational environments is data of the sort listed in the bottom parts of Table 5: data on teacher characteristics, program, curriculum, and facilities characteristics. The maintenance and processing of those data were not discussed in Section II, because of the limitations of the present investigation, and because the patterns of data maintenance are more variable among districts. But in implementation of a multi-level decision system, detailed considerations of those data, and the means by which they can be merged with student performance data to bring information to bear on educational decisions at all levels, is necessary.

In carrying out such design, it will become apparent that certain data necessary for decisions are not regularly maintained. For example, in many districts, information on size of each class is lost after the current semester or year. Other types of information may not even be obtained at any time. For example, certain family background

information such as father's occupation is often obtained only at one point in the child's school history, and never updated. Parents' education is obtained in fewer systems, and by methods which provide uncertain reliability.

Still other information may never be obtained as part of administrative data systems, though it is valuable for a multi-level information system. Regular surveys of teacher morale, for example, are almost nonexistent in school systems. The obtaining of such data for input to an information system is highly problematic. It will very likely not be generated unless mandated by a governmental authority, such as a state legislature; and it very likely should not be, unless one of the parties to education can make a strong enough case for such information to bring about such governmental mandate -- for the generation of such information is an administrative burden which should not be undertaken on a regular basis unless it is a definite aid to educational decisions.

In general, it is sufficient at this point to b alert to the problem of missing data, and the fact that the problem is not automatically solved by a remote access multiple-user data system. Certain standards for quantity and quality of information must be established through negotiation by the various interested parties.

Another kind of missing information is information generated outside the public school system, such as information on work experience and college experience. Such information is of direct interest to principals and superintendents; it provides information on the strengths and weaknesses of various school curricula on which further education or work performance is based; and it provides information valuable for guidance of students currently in school.

Although college records of students are not conceived as a direct part of the information system under consideration here, information from college records could be incorporated for most students who attend college. Most college attendance is within a short distance from home. The incorporation of graduates' performance in nearby colleges into information systems of the sort considered here is certainly feasible. More generally, the automation of administrative functions in colleges

will make far easier than at present the automatic reporting of student performance back to high schools. A few colleges currently make such reports; undoubtedly, the number will increase.

Reporting of high school graduates' work history is problematic, and at first would appear impossible. However, it is possible to obtain earnings histories for groups of high school graduates from the Social Security Administration, using procedures which prevent identification of individuals. At least one research project has used this method to examine employment and income histories of graduates of particular high schools (13). In a multi-level information system maintained by an information banker, it is likely that procedures for regular reporting of earnings for groups of graduates (grouped according to criteria of interest to the schools) could be established.

5. AGGREGATION AND ANALYSIS

Only for information on the performance of individual students, in column 1 of Table 1, which is necessary for decisions about individual students, is performance data in unaggregated form required. And only for information about the success of particular educational environments, in row 1 of the table, is environmental data in unaggregated form necessary. Data which are unaggregated both on the performance side and the environment side are useful only for decisions requiring information of type 1 in Table 1. Yet files as maintained and used by schools are unaggregated on both sides, for example, a student cumulative record which shows his performance in a particular class. This limits the usefulness of such a record to decisions involving that student in that class. For many educational decisions, information on particular students or particular programs is not necessary nor even relevant. Information must be at some stage aggregated before it is relevant to decisions that go beyond individual students or programs. The questions, then, concern the stages at which aggregation should occur, and the methods of aggregation. The usual pattern of information-aggregation in school organization at present is that information held at a given level is aggregated to the level just below. Schools maintain data on individual student performance; districts

maintain performance data aggregated as school averages; states maintain performance data aggregated as district averages. This rule of thumb holds as well for data on educational environments: schools maintain data on class sizes; districts receive and maintain data on average class size by school; states maintain data on average class size by district. When information is released to the public, it is in the form of school averages when released by the district, and district averages when released by the state. (Information is ordinarily not released by the school principal except for individual student information to the parent, for he usually has no authority to do so.)

A second characteristic of such data-aggregation is that it is nearly always carried out separately for individual variables. For example, student performance data are aggregated to give an average score; and class size is aggregated to give average class size. When data on state-mandated tests in California were published in 1968, district percentile test scores at grades 1, 3, 6, and 10, percent minority students in the district, and pupil-teacher ratio in the district were listed for each district.

This mode of aggregation is of extremely low utility for educational decisions. As a simple example, the percentile test scores at grades 1, 3, 6, and 10 reported in California invite inferences about changes in performance over the years of school between grades 1 and 10. For example, in the published California data in 1968, Oakland had percentile scores of 49, 40, 33, and 31 at grades 1, 3, 6, and 10. The inference of a decline in performance is invited by these scores; but the apparent decline could be entirely due to other reasons. If parents of high-achieving students moved out of the city as these students approached junior high and high school age -- a not unlikely possibility -- an aggregate result of this sort could be obtained even if the percentile scores of those who stayed in the Oakland system were <u>increasing</u> in percentile score over grades 1-10.

Such presentation also invites unwarranted inferences about effects of educational environments upon performance. The presentation of average pupil-teacher ratios in juxtaposition with average performance

scores invites unwarranted inferences about the effect of pupil-teacher ratio on performance.

The lack of utility of data aggregated to the level just below and on a variable-by-variable basis means that for serious inferences about effects of school environments intended to be useful for policy decisions, special "research projects" are necessary, which at great labor and expense collect unaggregated data on student performance and environments, and process these data in order to answer the research questions. If the correct system of data maintenance and aggregation were carried out to begin with, such special research projects would seldom be necessary.*

The technical question then becomes, what is a more appropriate way for data processing, file maintenance, and aggregation to occur? The answer is given by attention to two principles: (1) Data on each variable must be maintained at levels of disaggregation far below the level to which aggregation is desired, often at the level of the individual student, whose performance and educational environment are recorded; and (2) aggregation must be carried out by joint use of more than one variable.

The design for appropriate data-linkage and file-maintenance is discussed in Section IV; in this section, it will be useful only to give a few examples by which current data-aggregation and data presentation would be improved by correct procedures. As a first example, the appropriate way for test scores at grades 1, 3, 6, and 10 to be presented (to use the example of published California data) to allow inferences about decline or gain over the years of school is through a method of population-standardization developed by demographers. Although we will not go into technical matters in detail here, it is useful to give the outline of the way such a method operates, to give a feel for the disparity between current methods and correct methods.

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*One effect of this would be to put academic educational researchers largely out of work. This is probably as it should be, for many such researchers in the end ignore the policy questions and examine "more interesting" questions which lead to academic publication.

For each student at grades 1, 3, 6, and 10, the school has a grade 1 test score on a test comparable to that reported for current grade 1 students.* If the percent of current grade 1 students with a score of Y is X_1%, and the percent of current grade 3 students who had a score of Y on their grade 1 test is X_3%, then in creation of the population-standardized average score for grade 3, the current grade 3 score of each of those who had a grade 1 score of Y two years ago is multiplied by X_1/X_3. The end result after averaging these weighted scores will be a population-standardized grade 3 average which is based on a distribution of past grade 1 score identical to the distribution of current grade 1 scores. Carrying out a comparable standardization at grades 6 and 10 will give averages at grades 3, 6, and 10, based on a population with grade 1 test scores comparable to those currently at grade 1. Inferences about decline or rise based on school averages could then be appropriately made. If grade 1 test scores for current grades 3, 6, and 10 do not exist, then a similar population-standardization could be carried out using other characteristics of the students for which data exist both on current grade 1 students and current grade 3, 6, 10 students, characteristics such as race or father's occupation.

There is, of course, a conflict between the aims of aggregation to present the actual current state in a classroom, school, or district, and the aims of aggregation to allow inference about changes. The population-standardization described above allows more correct inferences about changes, but at the expense of showing the actual current state. This conflict of purposes should be recognized, leading to the following general principle: <u>Each aggregation and presentation of information should be designed for specific purposes, rather than as general-purpose datum</u>. The problems are very similar to those in index-construction

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*A somewhat different test may have been given, but the standardized score on two such tests ordinarily correlates very highly. The tests should be (and ordinarily are) normed for the same population, and standard scores (mean = 5.0, standard deviation = 1.0) should be used in establishing comparisons. A few students will have missing test scores at grade 1, and should be deleted from the calculation to be described. If a standardized test score is available at grade 2 for the students currently in grades 3, 6, 10, that may be used instead of the grade 1 score.

in economics, which require different standardization and modes of aggregation in order to be of value for specific uses. Description of procedures of index construction in economics, and references to further literature in economic index construction can be found in Eric Ruist (14); and foundations of index construction theory may be found in Frisch (12).

A more general examination of methods of aggregation and information-presentation to aid in measuring the performance in a given school or program is given in the companion document to the present memorandum, Measures of School Performance (D-19260-RC).

The essential characteristic of aggregation of the type discussed above is that it is aggregation of performance data alone; it does not relate performance data to characteristics of the educational environment. Thus it provides information of types 1, 2, 3, 8, or 9 in Table 1, on performance in particular environments or independent of the environment. It does not provide information of types 5 or 6, which aid policy decisions about types of programs or teachers.

In order to provide information of types 5 and 6 that is relevant to general policy decisions about types of educational environments, data processing that goes beyond standardization is necessary. It is necessary to establish explicit linkage between information on student performance, and information on characteristics of the educational environment. Referring to Table 5, it is necessary to make explicit use of information in the bottom sections of the table, much of which is currently maintained in different physical files from the information on individual student performance. The possibility of establishing such linkage without difficulty arises through the replacement of physical files by electronic ones, as discussed earlier. The procedures by which such linkage may be carried out are discussed in Section IV, 2, which provides a preliminary discussion of the file structure necessary for such a system.

The establishing of such a file structure is the first step in processing information so that it is of use to the various interested parties. The next step makes use of various modes of data-reduction. The principal characteristic of information systems designed to aid

decisions is massive data-reduction. A decision is typically an action taken from one of two or at most, a few alternatives; consequently, for information to be useful to that decision, it must be reduced to a few pieces of information, ordinarily from a massive array of data as a starting point. Numerous techniques such as regression analysis, factor analysis, analysis of variance, item analysis, discriminant analysis, and other statistical methods comprise the techniques by which large amounts of data are reduced and brought to bear on particular kinds of decision questions.

IV. IMPLEMENTATION OF A MULTI-LEVEL INFORMATION SYSTEM

1. INFORMATION NEEDS OF INTERESTED PARTIES

In order to give concreteness to the way in which a multi-level information system should be implemented, it is useful to give some examples of decisions confronting interested parties at different levels, which would be aided by such a system. Consequently, in the paragraphs below, a number of possible questions faced by various parties will be listed. Information on all of these questions can be provided by a multi-level information system, when fully implemented. Many of the questions, of course, would hardly be answerable with an information system in early stages of its implementation. Nevertheless, it is of value to present such questions here, because an idea of the kinds of questions for which information is needed should guide the development of an information system.

Questions are listed below of the sort that confront district superintendents, principals, teachers, and parents. No questions are listed for state and federal governments; these questions are general policy questions of a sort similar to those that confront a district superintendent. In parentheses following each question is a number referring to the type of information in Table 1, page 4, that is relevant to the question.

1.1. Superintendents

1. What are the benefits and losses of a new mathematics curriculum, in the long-term mathematics performance of students exposed to them? (3)

2. How effective in other districts is a remedial reading program with a special teacher, and for what kinds of reading deficiencies is it most effective? (5,6)

3. What is the impact of flexible scheduling, as used in other districts, on the course performance, standardized test performance, and motivation of students, and the satisfaction of teachers? (6)

4. What is the effect of a program of affirmative racial integration on performance of students of different races? (5)

5. What are the effects of a curricular innovation introduced in some districts, such as simulation games in social studies? (2,3)

1.2. Principals

1. Of the various physics curricula in use in surrounding schools, how do they compare with respect to (a) the course performance of students as measured by grades; (b) their effects on performance in physics as measured by standardized tests; and (c) their effects on performance in college physics? (3,6)

2. What are the increments in reading performance among students exposed to different reading programs used in surrounding schools, and how do these increments hold up in succeeding years? (3,6)

3. Should teacher A be assigned to high-achieving students or low-achieving students? (2)

4. What is the difference in learning of mathematics when scheduled early in the day, rather than late? (6)

5. What difference in achievement and motivation exists between a joint social studies and English course and separate English and social studies courses? (6)

6. How does participation, in particular extra-curricular activities affect the motivation, attendance and performance of students with various types of school records? (2,5)

7. What is the effect of a poor grade in one subject on subsequent performance in other subjects? (8)

8. How can impending problems for a student be anticipated by an "early-warning system"? (9)

9. Using school grades rather than standardized tests as a criterion, are there any characteristics of teacher and student such that matching on these characteristics will improve performance? (5)

10. Does an increase or decrease in the level of parent involvement in school activities, as experienced in other schools, affect the general course performance of students? (6)

1.3. Teachers

1. In a given test or set of tests, what items are missed by a large proportion of the students? (3)

2. What are the characteristics of those items missed by a particular student? (4)

3. For children who are in the bottom quarter of the class in reading, what aspects of mathematics are they doing most poorly at? (elementary level) (2)

4. For the students at the bottom quarter of the class in my subjects, what is their average performance in other subjects they are currently taking, and in this subject last year? (2)

5. In a machine-scored quiz devised in conjunction with another teacher, which of our classes wins in average performance? (3)

1.4. Parents and Children

1. How is my child progressing, not merely in his school grades, but in his performance relative to national norms? (1)

2. What is the expected reading level 2, 3, 4 years hence for a student in this school with reading level the same as my child's at present? (2)

3. What kinds of supplementary help are beneficial for children who show a profile of performance comparable to that of my child (e.g., such help as oral reading practice, mulitiplication drill)? (5)

4. What is the expected grade in algebra 2 in this school for someone with a given set of grades in algebra 1? (2)

5. What kinds of college programs or careers are likely to be successful for someone with a given profile of abilities and interests? (5)

6. What has been the average level of performance of students from this high school with a particular set of grades and college board scores in a given college? (2)

There is also a set of questions that parents and children would have if they had an expanded range of choice concerning schools, programs, and teachers than they currently have. There are a number

of indications that parents may come to have a greater range of choices, through such means as tuition vouchers for attendance at a school of their choice with public funds, released time or after-school time for special instruction with public funds; choice of teacher, subject to class size limitations. If such expansion of choice did come to exist, one of its most important adjuncts would be information aids for the parent and child, to give them objective information on which to base choices.

7. What has been the performance increment in reading by national norms of children under various teachers that my child might have next year? (3)

8. What is the record of a given school in the performance increments of its students on nationally-normed tests? (3)

9. What kind of reading program is best for a child who shows a performance profile like that of my child? (4)

These questions give an idea of the kinds of problems to which an information system can be relevant for various parties. In order to move closer to realization of such a potential, it is useful to examine two aspects of the system: the structure of data files, and organization of communication; and the organization of equipment required by a multi-level information system. These two aspects of system design will be discussed in the two remaining sections.

2. FILE STRUCTURE AND DATA ORGANIZATION

2.1. File Structure and Code Assignment

There are numerous sources for the data collected and maintained in an educational data system. These data are typically collected independently of and in isolation from each other. Yet for many purposes, the appropriate presentation of these data involves classification across sources. One example is the classification of a student performance indicator, contained in the student file, by some characteristic of his subject teacher, contained in the teacher

data file. In order to present this information, the necessary linkage between the student and teacher data must be made.

When these sources are physically stored, this linkage is accomplished by the transcription of the needed data from one source to another. This transcription may necessitate re-ordering the data or casting it in a different format; consequently, when cross classification is needed, special projects are undertaken to provide the linkage.

With electronic storage of data, direct linkage between separate sources becomes possible without physical relocation. Before describing how such linkage could be implemented, a brief discussion of computer files is in order.

Often in computer applications, the core storage of the computer is not sufficiently large to store at one time all the data required for the problem. In this case storage devices such as tapes, disks or drums may be used to augment computer storage capability. A logical grouping of data contained on one of these devices is called a file. These files are organized similarly to physical files. For instance, all the data maintained for students in a school make up a student file. Files are composed of records, which are the units of the file accessed by the computer at one time. A record in the student file would typically contain data for one student. If there are 2000 students in one school, there would be 2000 records in that student file. Records are made up of variables, for instance the student's name, age, mathematics achievement score are possible variables contained in each student's record.

There may be more than one type of record for each unit in a file. For example, student data may be in several student files: one containing academic information, another containing health information, and a third containing extra-curricular information. (Alternatively, certain information may be filed by the activity, with the students who participate in the activity contained in the record of that activity.) The optimum mode of filing depends on the principal ways in which the files are accessed,

just as in physically organized files. However, the difference lies in the ease with which multiple modes of access can be carried out. In physical files, cross-file access is measured in hours or days of search, sorting, and copying; in electronic files, such access is measured in milliseconds.

The number of units for which there are records and the number of types of records may vary widely in files. In student files, there are many students, and a single record or a few records per student. In a file containing school variables maintained at the school, there is only one school, but many records; in such a file maintained at the district, there are several schools, and many records for each.

There are a number of ways in which data from various files may be linked. In order to examine effects of teacher characteristics on student performance with school and district characteristics controlled, for example, it is necessary to link together records on individual students, their teachers, their school, and their district.

Such linkage might be carried out in several ways which will be discussed briefly. The first and simplest structure is a totally nested system. If a system is fully nested, so that each unit at a given level is a number of one and only one unit at each higher level, then a code may be assigned to each level, with uniqueness maintained only within level. Thus for a student in elementary school in a given classroom, a student's code may consist of his code within class (2 digits), a classroom code within school (2 digits), a school code within district (3 digits), a district code within state (3 digits), and a state code (2 digits). This provides each student a unique code within the country, and allows student records to be linked to teacher, school, district, and state records through use of the appropriate segment of his identification code. The code is longer than would be necessary if he were simply assigned a unique code within the country (12 digits rather than 8), but the code for units of which he is a member need not be included elsewhere in his record.

For example, consider linking up teacher, school, district, and state information for student 15 in classroom 03 in school 081 in district 385 in state 23. The unique codes would be for records at the various levels:

Student	23 385 081 03 15
Teacher	23 385 081 03
School	23 385 081
District	23 385
State	23

If a system is fully nested, but there is sequential mobility within it (i.e., a unit such as a student is a member of one and only one unit at each higher level, but may move from one to another), then two possibilities are available. The code used in a fully nested system may be used, and changed when the unit moves, just as an individual's street address changes. Or a code may be assigned uniquely across higher level units, between which mobility occurs. For example, if there is high mobility of students and teachers between schools in a district, each student and teacher might receive a unique code within the district, rather than a unique code within the school. With this coding system, linkage of student records with school records can be achieved in either of two ways: by containing within the school record a list of the codes of all students currently in that school, or by containing within the student's record the school code for the school he is currently attending. The decision whether to use the fully nested code or to embed student or school codes in school or student records is a decision that must be made on the basis of the most frequent types of use of the records.

Finally, a system may have a structure that is not nested: one unit may simultaneously be a member of several higher-level units. For example, a student in high school has more than one teacher at the same time, but not a fixed number. In such a structure, the teacher's code cannot be a part of the student code, since the student has several teachers. In this case, the only solution is either to incorporate within the teacher record the codes of the students he is currently teaching (codes which may be unique within

school, district, state, or nation), or to incorporate within the student record the codes of the teachers he currently has (or possibly both, if file storage is less costly than the extra cost of inconvenient access). This non-nested structure is appropriate for many of the activities which occur in education, since each student and teacher is engaged in a variable number of activities.

An example of how a non-nested structure might be used to link data from different files together is the linkage of student grades and standardized test data to characteristics of that year's teacher in that course. The teacher's record contains the teacher's identification code and the characteristics of that teacher. The course code, the grade earned, the teacher code, and standardized test results are all recorded in the student's file. The course code would include codes for subject area, course name, course section, teacher. Course section might incorporate ability-level code, if used. As an example, the code for section 7 of English 10B, 001-010-07-030, would be built up from:

Subject area = English = 001
Course name = English 10B = 010
Course section = 7th period = 07
Teacher name = Alice Jones = 030

In a similar manner, a standardized achievement test in the related area might use the following identification code:

Subject area = English = 001
Standardized test name = TAP-1 = 020
Time test was given = March 69 = 0369

To find the relationship between teachers' characteristics and the students' grades and standardized test scores, linkage is provided with these identification codes, using a procedure somewhat as follows. Find data for subject code 001 in each student's record; retrieve grade and test information; use last portion of course name, i.e. teacher's code, as locator of this student's teacher's record within teacher file; retrieve teacher's characteristic (in this example verbal ability). Figure 1 is a diagram of this linkage.

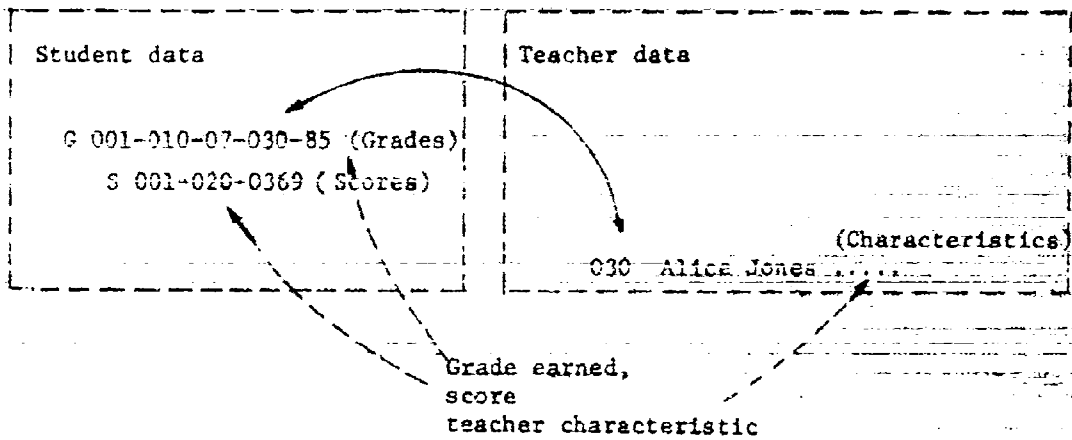

FIGURE 1

2.2. File Security System

In implementing a multi-level information system, guards against illegitimate access to data must be built in as part of the file structure. Files may be designated as public information and thus accessed by anyone, or files may be designated as proprietary information with ranges in the amount of access provided. Access to proprietary information is gained either by typing in a password or by using a terminal which the system has validated as accessible to given information.

In one password system, there are procedures for insuring medium and maximum security. In medium security, the user gains access by typing the name of the file and the required password(s). A maximum security file requires, in addition, appropriate answers to queries posed by the program. For example, (16, p. 3):

> PASSWORD(S) <u>BARKER</u>, <u>FOXTAIL</u>, <u>CREDENZA</u>
> WHO ARE YOU? <u>***9</u>
> HOW OLD ARE YOU? <u>NINETY**</u>
> MOTHER'S MAIDEN NAME? <u>SMITH</u>
> SMITH? <u>JONES</u>

The underlined portions are user's answers to questions. If he had answered any of these incorrectly, he would not have gained access to the file he was requesting.

Limits of Access

The passwords prevent unauthorized access to a file; there are also provisions for different limits of access.

1. USE ONLY

The user may use the data under the control of specific programs, but may not gain access to the individual elements of the file. The program may compute averages or differences, for example, and transmit these to the user.

2. READ ONLY

The user may read the data file, list its contents, and copy into another file.

3. UNLIMITED ACCESS

The user may not only read the file, but also change the file.

2.3. Organization of Communication

In an information system with many source points for data and many users, the structure of communication provides non-trivial problems. In the system of public education in the United States, there are ordinarily three major types of source points: the teacher or counselor, the principal or school central office staff, and the superintendent or district central office staff. All these source points are potential users of information from the system as well. In addition, there are users outside the formal system: the state and the federal government (sometimes for administrative functions, sometimes for research questions relevant to general policy decisions), parents and students, and personnel in other districts. The patterns of access and the modes of access to any information must obviously be specified in full detail.

In beginning such specification, a few basic principles can be established. First, each party who constitutes an originating source has a file or set of files associated with him. Second, only the person who is this originating source, who creates and maintains this file or set of files, has unlimited access to all portions of it.

Third, there must be a read operation from file to file, reading specified subsets of the information from one file (e.g., a teacher's file) into another file (e.g., a school file), an operation that occurs at specified times. This operation should be carried out automatically, under procedures audited by the information banker. Fourth, for all users of information, there should be use-only access through specific aggregating, analytical or administrative programs, which use file information to serve the user's needs.

These principles are illustrated in a diagram which shows the patterns and types of communication through the information system.

Figure 2 contains paths of flow of information between (1) data originator and data file, (2) data file and data file, and (3) user and data file. The paths are of the three varieties corresponding to the limits of access: unlimited access, read-only, and use-only, respectively. Solid lines with arrows in both directions indicate unlimited access; long-dash lines with a single arrowhead stand for read only access where the arrowhead points to the destination file; and finally short-dash lines with a single arrowhead represent use-only files with the arrowhead pointing to the destination. Any flow of data along a long-dash line refers to the automatic updating of a file as a result of a specified procedure. A short-dash line represents flow of data which is under user request. In the diagram, the files at each source point are represented as a single file; but in general, there will be several files at every source point which differ in accessibility.

To exemplify communication along these paths, we may begin with the principal's office scheduling students for classes. This operation, which results in a file entry in the principal's file, also creates class rolls for each teacher. If each teacher has a file and a terminal, as assumed in this figure, the class rolls are automatically transmitted along path 2, from the principal's file c to the teacher's file a. If the teacher does not have a terminal and file, as might be the case in an initial equipment configuration, the class roll is physically transmitted to the teacher, after the schedule is stored in the school file. Once the class list is

entered into the file, this establishes the framework for this teacher's student data file. This teacher alone has unlimited access to this student file and may enter whatever data she deems necessary or appropriate (path 3). Not all the data she enters are accessible by the school file or the principal. The principal has access to specified portions of the teacher's file by two means. First, information for special purposes may be requested by the principal via path 5. Second, the school file, c, is updated automatically via path 4 with certain specified data from the teacher's file. Data transmitted over path 4 consists of such items as grade reports and attendance reporting. Teacher consultation of the central school file is carried out via path 1, according to the rules of access in the school. The teacher may also use the district file via path 14 to obtain information or more general questions concerning curriculum, student performance, etc., as outlined under 1.3. in this section. The teacher may also use the information bank, the filter for information from other districts, for more general questions (path 13).

The teacher's file is accessed by one other party, the parents, who have use-only access via path 6 to specified portions of the teacher's file containing certain information about their own children. Physically, the parent's access would be through a terminal at the information bank. (In addition, parents have access to more general performance information concerning their child and guidance information involving data beyond their own child, from the information bank, via path 7. Upon such parental requests, the information bank (file f) accesses the school file via read only access for information on that child, through path 8.)

In an initial system in which teachers do not have individual terminal equipment, their information on grades, attendance, etc., would be kept in a gradebook as at present, and periodically entered into the school file through mark sense cards or similar means. The teacher would use a school terminal for information requests represented by paths 1, 5, and 6, and might maintain a private file accessed by a school terminal. If several terminals existed at different points in a school, full implementation of teacher files as in Figure 2 would be possible without individual terminals.

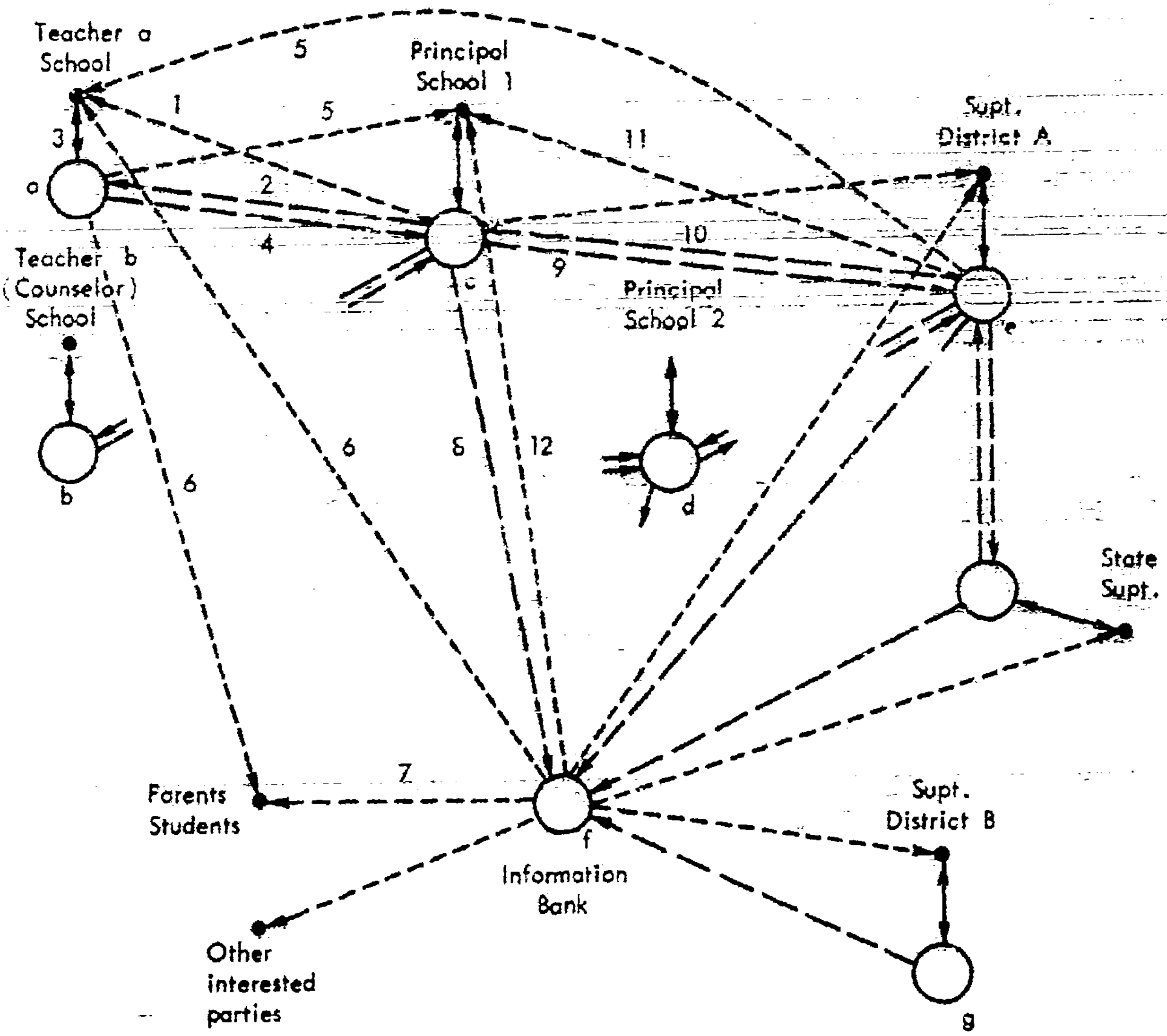

Fig. 2—Communication flow

The principal's use of the system would be most intensively through use of the school files, (which are automatically updated via path 4 from teachers' files and via path 9 from district files, and from which information is automatically transmitted to district files and the information bank.) For requests involving information from other schools in the district, the principal accesses the district file in use-only mode, and for requests involving information outside the district, he accesses the information bank via path 12.

Use by the district superintendent's office is as indicated by the figure, and requires little elaboration. The state education department's files are periodically updated by district files and periodically transmit state administrative information to those files. In addition, the state makes information queries for research and evaluation purposes as does the district superintendent, through the information bank, using the information to which the bank has access from various districts both within and outside the state.

The information bank is also accessible by other interested parties whose access to the bank is legitimated. These parties may be a research or statistical division of the U.S. Office of Education, committees of the state legislature or Congress, or research branches of other organizations in the community. Obviously, it is necessary for rights of access and limits of access to be clearly defined for such multiple use to occur.

This initial outline of the organization of communication in a multi-user system of this sort gives a view of the general patterns. The details of the system will differ in different applications, and will obviously depend also on the configuration of equipment as discussed in (3.) below. Before that discussion, however, it is useful to mention briefly two other aspects of the system that are relevant for research and evaluation purposes: experimental designs and data sampling.

2.4. Experimental Designs As a By-Product of Scheduling

In an information system based on administrative data, analysis of the performance of students in different environments must ordinarily

take the assignment of students to particular environments as given, and use statistical controls to reduce incorrect inferences based on initial correlations between variables. Strict experimental design, with random assignment of students to different environments, is ordinarily not possible, since the school is an ongoing system, with assignment made for a purpose. However, this overlooks one point: many assignments are not made for a purpose, but are made arbitrarily. And when assignments are made arbitrarily, they may be made randomly, with no loss in administrative intent. When a student chooses a course for which three different classes will fit the remainder of his schedule, then if scheduling is done manually, he is arbitrarily assigned to one of the classes. More generally, in working out a schedule, a number of arbitrary decisions are made, especially in the initial stages of the process, in order to provide a frame within which other courses can be fitted. When scheduling is done by computer, arbitrary procedures are also used in such circumstances.

Whenever such arbitrary procedures are used, then the arbitrary procedure can be so designed that the canons of experimental design are met in assignment. Whenever such an arbitrary or random assignment is made between particular alternatives, the assignment and alternatives can be recorded. At the end of a computerized scheduling process, a number of random assignments will have been made among several sets of alternative environments. For each set of alternatives among which random assignments have been made for two or more students, an experimental design exists. Thus a scheduling program may give as a by-product several experimental designs, which can be automatically stored until performance data on standardized tests are obtained during or at the end of the course. These courses may differ in a number of ways: characteristics of teacher, characteristics of classmates, time of day, and sometimes textbook or curriculums. By amassing experimental results over a number of semesters and a number of school, strong inferences can be drawn about the effects of particular characteristics of the environment, inferences that could not be as sound without knowledge

concerning which assignments were randomly made and among what set of alternatives.

The procedures used by some existing programs for scheduling students when two or more options are open differ somewhat from random assignment, but in ways which could be easily modified. For example, IBM's scheduling program, CLASS, which schedules all courses for each student before proceeding to the next student, assigns him first to classes in which there are no alternatives. It then moves to classes in which alternatives exist, and assigns him to the section in which most seats remain. It is only this last step which requires change to insure random assignment: he must be scheduled randomly among a well-defined set of courses, rather than according to a characteristic of the course.

The SOCRATES scheduling program does not schedule all courses for a student before proceeding to the next, but schedules first the courses for which there is only one alternative, second the courses for which there are two alternatives and so on, at each point revising the number of remaining alternatives as available alternatives are preclosed. This program is directly modifiable to allow recording of random assignment, merely by recording the two or more alternatives that exist for each assignment in which a student is randomly assigned to one alternative out of two or more. (See reference 19.)

Such emerging possibilities allow for creative work in statistical methods. Here is not the place to begin such work. It is enough to note that scheduling programs, appropriately designed, allow experimental designs of radically new forms, purely as a by-product and without altering the criteria on the basis of which class assignments are made.

2.5. Data Sampling

For many information problems for which the information system is designed, there will be far more cases of student exposure to a given environment than are necessary for statistical reliability. It is characteristic of schools that many students are exposed to an educational environment that is identical in its measured aspects.

Consequently, for efficient analysis of data, it will often be necessary to use sampling procedures. The specific methods of sampling will differ according to the problem; but sampling programs will be necessary to use in conjunction with the file structure described above, in retrieving a set of data for analysis.

3. MACHINE CONFIGURATION

In order to partially automate school administrative activities, a number of different machine configurations are possible in a school and district, some of which are described below. What is essential for an information system of the sort under consideration is electronic file storage and remote communication capacity. This becomes feasible with little capital expenditure through the purchase or rental of terminal equipment for the school and district offices, and rental of computer time and file storage from a central computer service whose costs are distributed over all users. As will be evident in the discussion below, such a file storage and communication system is possible with nothing more than a teletypewriter, but because of inconvenient data input and slow printed output is probably efficient at the school level only with a card reader and remote line printer in addition, described as station 4 below.

3.1 Possible Remote Station Configurations

The monthly rental for a modest size computer falls in the \$2000-\$4000 range. Such a computer would be adequate for carrying out the administrative activities in a school described in Section II, as in the example of Norwich Free Academy; but it is too expensive for a single school and lacks remote communication capability, requiring on-site access. However, the availability of commercial time-sharing services and service bureaus, and regional educational computing centers, provides a way for school districts to begin computer usage without a large initial expenditure.

A computing service underwrites its monthly computer rental and other expenses by renting computer time to various subscribers. A

school district, for instance, may rent time from such a service to run a scheduling and grade reporting program. The school district would then be charged according to the amount of computer time it used in running these programs.

There are many services from which a school system as a potential subscriber can choose. In some states there are regional computing centers providing services specifically tailored to the educational area. Time sharing services, designed to permit interactive use of the computer, are widely available commercially. In addition, other service bureaus providing batch processing services are available.

The mode of computer access, for instance batch processing, time-sharing, or dedicated system, sets out a range of equipment configurations available to the school district. With a service providing batch processing capabilities, no equipment, or very little (keypunch, sorter), would be necessary at the school, but only activities requiring infrequent computer use--such as scheduling--are feasible. To use a time-sharing service, however, the minimum equipment is a teletypewriter.

Since the mode of access bears directly on the possible district configurations, to prevent being too restrictive, a very general computer capability is assumed. Specifically, we assume the existence of a large central computer receiving inputs either locally or from remote stations. Various input/output devices are located at the central computing center, specifically a high-speed line printer, card reader, and puncher, magnetic tape units and disk storage units. These devices may be used by the remote user as well as the local user. In addition, the remote user may have his own input-output devices located at the remote station. These remote devices may receive and transmit data to and from the central computer. It would be possible, for example, to request (by means of the teletypewriter) that a tape physically located at the central computing center be read and the data transmitted and be listed on the line printer at the remote computing station. These remote stations may contain a teletypewriter, a card reader, and/or a line printer.

This discussion will consider four of the possible types of stations for this computing facility. These are built up from the separate

components (teletypewriter, line printer, card reader) in hierarchical fashion--that is, station 1 is contained in stations 2, 3, 4; station 2 is contained in stations 3, 4; and so on. These stations provide a hierarchy through which a school may progress. All four stations and combinations of these four may exist simultaneously within the system. Figure 3 illustrates the four stations and their linkage to the central computer.

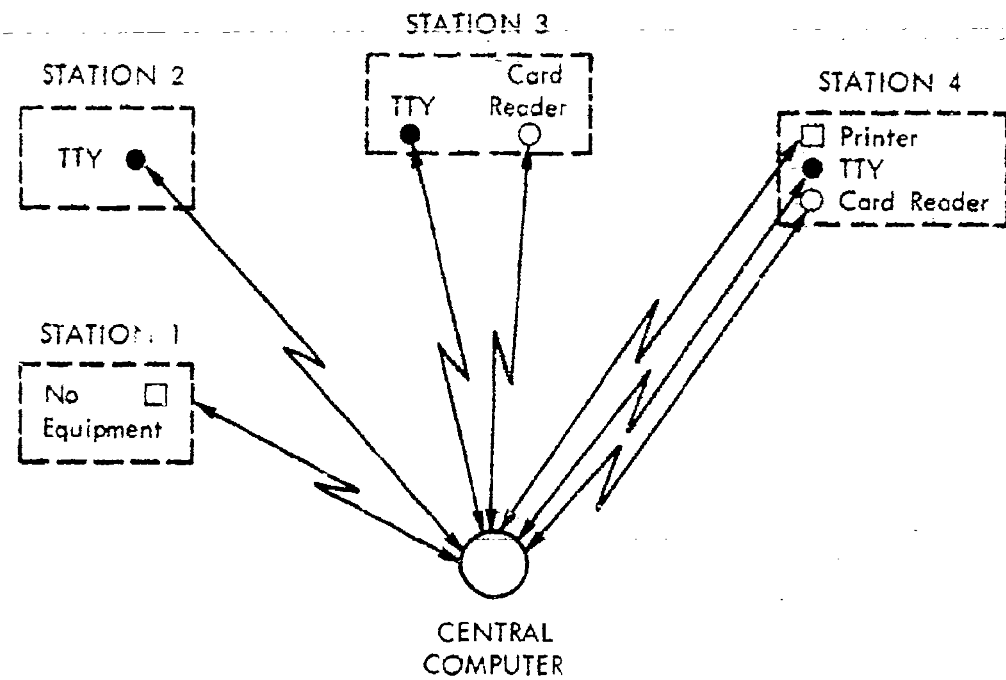

Fig. 3—Remote computing network

3.1.1. Station 1: No equipment

Initially, a school may not have any equipment at all installed. In order to gain access to a computer the user must commute to the

central computing facility. He submits his job and after completion, returns to pick it up. The time between job submittal and completion depends on the efficiency and schedule of the computer center, and may range from less than an hour to more than a week. This arrangement precludes interactive use of the computer.

3.1.2. Station 2: Teletypewriter

Teletypewriters are widely used as input devices by commercial time-sharing services. The availability of acoustical couplers on these units allows using any regular telephone to link the terminal to the computer. Consequently, these units may be used wherever there is a telephone. Relocation of teletypewriters is hampered by their 75-pound weight. However, lightweight models costing about the same will be available in early 1970. Teletypewriters contain a paper tape punch which allows programs and data to be stored for later use or reference on punched paper tape. The data limitations lie in the low speed of the tape reader.

What advantages are offered by configuration 2 over configuration 1? In principle, all capability of remote usage is available, but the low input and output speeds limit this usage to low-volume applications. Schools may use the teletypewriter for remote job submittal, saving the time and inconvenience of commuting to the computing center. Secondly, all the advantages of the interactive capability of a time-shared system are available. One area which currently is benefiting from this interactive capability is counseling. There are numerous projects which are using computer assistance in counseling. A library of career information, along with methods to explore this information, is given to the students. One system, Computerized Vocational Information System in operation at Willowbrook High School, Villa Park, Illinois, asks the student about his interests and post-high school plans, and then lists available jobs fitting these categories. Then the student may request additional information about any of these jobs. (18, p. 76)

3.1.3. Station 3: Teletypewriter, card reader

There are several card readers available for transmitting card data from a remote location to the central computer. These readers read both punched cards and mark-sense cards. Addition of a reader considerably increases the flexibility of station 3 in comparison with station 2. When typewriter or paper tape is the only means of data origination, there is no convenient way to provide remote input to the computer. With addition of the card reader a very versatile and portable storage medium, the punched card, is added to the local system. Teachers, for instance, may have their students record quiz answers on mark-sense cards, and receive test grades and tabulations of errors for each item within a few minutes after test-taking. Procedures such as attendance reporting, which must be done daily and consequently have very limited time for completion, would benefit from a local card reader. The local availability of a card reader makes possible quicker service and easier access.

3.1.4. Station 4: Teletypewriter, card reader and printer

Remote line printers are available and would be necessary for printing any large volume of data at the local station. The slower speed of the teletypewriter makes this device very poor for printing large volumes of data. For example, one estimate states that it would take four teletypewriters 24 continuous hours of operation to print report cards for 2000 students. (11, p. 74.)

With the incorporation of a line printer the station would be able to transfer all jobs and data to the computer for processing and then receive the results at the local station. For most of the pupil personnel procedures described in Table 3, page 21, this configuration would be adequate.

Table 6 gives the monthly rental, purchase and particular characteristics known about the station components.

Table 6

STATION COMPONENTS

Rental, Purchase, Characteristics

Component	Rental (Monthly)	Purchase	Characteristic
Teletypewriter and coupler	$ 70	$1500	10 characters/second
Card reader (punched cards only)	$100	(a)	100 cards/minute
Card reader, punched cards, mark-sense cards	$160	(a)	100 cards/minute
Line printer	$400	(a)	300 lines/minute

[a]Data not available.

4. ADMINISTRATIVE PROCEDURES FOR PUPIL PERSONNEL ACTIVITIES IN A FULLY AUTOMATED SYSTEM

The next section describes some aspects of pupil personnel procedures in a multi-level information system, assuming the existence of teletypewriters available to teachers, and a remote card reader and line printer located at the school office and at the district office. These descriptions are intended to give a sense of the way in which some of these procedures would be carried out differently in such a system than they are with data systems that are manual, or those that use non-interactive modes of computer access.

4.1. Scheduling

After preparing the student request cards and master schedule cards on either punched cards or mark-sense cards, these cards are read by card readers at the local station and transmitted via phone lines to the central computer and the scheduling program. The scheduling program uses these data and prints the course conflicts, teacher load, and other available measures of adequacy of the schedule on the printer in the school office. Next, the program asks the human scheduler (via the teletypewriter) if this schedule is satisfactory, that is, the

final one. If not, he answers no, but instructs the computer to store his schedule as it stands on the disk file. Then in the next run, only change cards--not the entire file--will have to be read from the card reader. When the human scheduler is satisfied with the schedule, he answers "yes" and the computer then prints the schedules for all students in th. school and automatically updates each teacher's file with the class roster for each course.

If sufficient teletypewriters were available, the students with their counselors could enter their course requests via teletypewriter and immediately learn whether or not the course were available. This system would work in a manner similar to other reservation systems, such as airline or hotel systems. Each student would be scheduled as he selected his courses, and changes necessitated by irresolvable conflicts would be made immediately.

4.2. Attendance Reporting

Teachers may record a student's absence in much the same manner as in a partially automated system, that is, by sending a prepunched card containing the student's name to the school card reader. Or, if teletypewriters are available, a teacher would record absences directly via teletypewriter. Master lists of absences are printed at the school on duplication masters for reproduction and distribution through the school. The student master file is automatically updated with this attendance information. A counselor or teacher may request an attendance profile for any student (e.g., Mary Jones) by typing on the teletypewriter:

FIND: Attendance: Mary Jones

The current attendance profile for Mary Jones would then be printed on the printer.

4.3. Grade Reporting

A teacher enters her students' grades in her teacher file either by recording them on mark-sense cards or by entering them on the teletypewriter. When grade reports are wanted, the teacher requests that

the computer average her students' class grades. Since all the grades have been stored in a computer "gradebook," the teacher need not enter these grades. She may apply differential weighting to the tests, and will then obtain summary statistics for her class--the mean, standard deviation and ranking of students, for instance. After verification of these reports, the teacher indicates that report cards should be printed and the students' cumulative records should be updated with these data. If any additional reports are needed by the teacher, the data system would be organized so that this could be done easily and quickly. For example, a vocabulary for report generation of this sort could be established. To obtain the rank of students in her English 10B class, the teacher would instruct the computer to

RANK: English 10B

or, to ask for students with one failure, a counselor might type

FIND: Failures (1)

4.4 Testing

Students may record their test answers on a mark sense-card which the computer reads, scores and stores on tape or disk. Alternatively, the student may sit at a teletypewriter which asks the student a question, records his answer, and at the completion of the quiz stores his "test sheet" and his score on tape or disk. Besides the scoring and recording features, in a data system design which includes automated testing, there can be additional capability which provides the teacher or school administrator analytical tools. For example, item analysis of tests may be a part of the testing procedure. In addition, such systems could provide a data bank of questions used by teachers of this particular course. The teacher could select questions and have the test automatically printed on duplication masters.

APPENDIX A

Appendix A contains a discription of the tape format of the student master file for the California Total Educational Information System (2, B-2 - B-5).

TAPE FILE A-1 (School Student Master File)

CHARACTER POSITIONS	FIELD CONTENT	FIELD DESCRIPTION
1-8	School Identification	The first two positions number code the county; the next three, the district; and the last three, the school within the district.
9-18	Student Number	The first position is an alpha character; all other positions must be numeric.
19	Student's Attendance Category	0-8, type of class enrolled in; or A-H, J-L, length of daily kindergarten.
20-21	Beginning Attendance Month	The first month student attended the school for current school year.
22-31	Blank	
32-51	Student Name	Self-explanatory (Last name first)
52-91	Student Residence Address	The first 20 positions denote the street; the next 15, the city; and the last 5, the ZIP code.
92	Student's Sex	M or F
93-99	Blank	
100-109	Student's Telephone No.	Area code and number
110-114	Birthday	Month (1-9, O, N, or D), Day (two positions), Year (two positions)
115	Blank	
116-127	Birth Place	City or City and State
128-129	Blank	
130-134	District of Residence	The first two positions denote the county and the last three, the district.
135-162	Blank	
163-164	Entry Code	Enroll/Withdraw code. If the student is enrolling, use the following code: E1 = Students enrolling for the first time in public school this year. E2 = Students enrolling for the first time in a California school this year. E3 = Students enrolling as a transfer. E5 = Students enrolling through scheduling procedure. R = Student enrolling as a returnee this school year. E6 = Students enrolling in private or parochial school for the first time this year.

TAPE FILE A-1 (cont). (School Student Master File)

CHARACTER POSITIONS	FIELD CONTENT	FIELD DESCRIPTION
163-164 (cont)	Entry Code (cont)	E7 = Students enrolling for the first time in a private or parochial school in California.
		E8 = Students enrolling as a transfer from a private or parochial school.
		If the student is withdrawing from school, use the following code:
		L1 = Transfer to high school within district.
		L2 = Transfer to district within county.
		L3 = Transfer to district outside county.
		L4 = Transfer to continuation high.
		L5 = Transfer to adult classes.
		L6 = Transfer to CYA or county probation.
		LA = Moved, no request for transcript.
		LB = Exempt, parents' request.
		LC = Health, including psychological.
		LD = Married.
		LE = Pregnancy.
		LF = Work.
		LG = Military.
		LH = Over 18.
		LJ = Over 16.
		LK = Suspended (end of term).
		LL = Expelled or excluded.
		LM = Others.
		LN = Unknown.
		LX = Administrative.
		LZ = No show.
		RH = Return from home.
		HT = Home teaching.
165-169	Entry Date	Date student entered system.
170-174	Date Left	Date student left system.
175-176	Leave Code	Explains reason for leaving.
177-180	Blank	
181-200	Parent or Guardian Name	Self-explanatory

TAPE FILE A-1 (cont). (School Student Master File)

CHARACTER POSITIONS	FIELD CONTENT	FIELD DESCRIPTION
201-220	Emergency Contact	Parent or guardian's address.
221-230	Emergency Phone	Self-explanatory.
231	Polio	X, R, or O (immunized, religious restriction, or not immunized, respectively).
232	Health	1-9 (according to any coded health condition).
233	PL874	X or O (under public law 874 or not, respectively).
234	DR-TR	X or O (completed driver training or not, respectively).
235	First Aid	X or O (completed first aid course or not, respectively)
236	Ethnic	1-6 (according to coded ancestry).
237-261	Blank	
262-275	Counselor Name	Self-explanatory.
276-295	Monthly Attendance Picture	Five positions are allotted for each of four weeks of the current month to denote presence, absence, or holiday for each day of each week.
296-305	Yearly Attendance Picture	Two positions are allotted for each accumulated day of the week to denote number of times absent.
306-314	Total Yearly Absences	Three positions are allotted for the number of days absent within each of the following categories: sick, unexcused, and not enrolled.
315-317	Apportionment Days	Number of days student actually attended schools.
318-373	Sequence Numbers and Marks	Seven positions are allotted for each of eight courses; the first three positions for each course denote the sequence number, the last four, the mark.
374-386	Achievement Test Data	The first four positions denote the test ID number, the next two codes the form used, the next two denote the test level, the next four positions denote the month and year the test was given and the grade (K or 1-12), and the last position denotes the NORM (the average grade obtained by students of the same level as this student and taking the same level test).
387-476	Scores for the Ten Sections of the Achievement Test	First five positions denote bucket or sub-test number, and the last four denote the sub-test score (repeated fields for each sub-test).
477-489	Aptitude Test Data	Same type of data as for positions 375-387, above.
490-498	Language Score	For the aptitude test.
499-507	Non-Language Score	For the aptitude test.

TAPE FILE A-1 (cont). (School Student Master File)

CHARACTER POSITIONS	FIELD CONTENT	FIELD DESCRIPTION
508-516	Total Score	Last two scores combined.
517-520	Room Number	Self-explanatory.
521-526	Blank	
527-529	G.P.A.	Grade Point Average
530-533	Sort Room No	Number for sorting by classrooms.

#0-847

APPENDIX B

California Administrative Code, Section 79a, requires:

a. Name of pupil.

b. Date of birth, if pupil is a minor.

c. Method of verifying birthdate of pupil being admitted to kindergarten or first grade.

d. Place of birth.

e. Name and address of parent having custody, or guardian if pupil is a minor.

f. Entering and leaving dates for::

(1) Each school year.

(2) Each summer session which provides credit.

(3) Each extra session which provides credit.

g. Subjects taken each year or half year.

h. Marks or credits allowed toward graduation.

SANTA MONICA, CALIFORNIA

CUMULATIVE RECORD

Junior and Senior High Schools

(PHOTO)

SAMPLE CUMULATIVE RECORD

Grade	B7	A7	B8	A8	B9	A9
School	Malibu Park	Malibu Park	Malibu Park	Malibu Park	Malibu Park	Malibu Park
Date of Entering	9-16-63		SEP 14 1964	2-1-65	9-13-65	1-31-66
Date of Leaving	1-31-64	6-17-64	JAN 29 1965	6-18-65	1-28-66	6-17-66
Attendance (Absence)						
Subject	Course Title / Mark	Course Title / Mark	Course Title / Mark	Course Title / Mark	Course Title / Mark / Units	Course Title / Mark / Units
Art						
Business Education			Typing A-	Typing A		
English	A-	A	B	Cr. Writing B	Eng I B 5	Eng II B 5
Foreign Language	French A	French A-	B-	French B	French IX B 5	French II A 5
Home Making	A	A				
Industrial Arts						
Mathematics	A	A-	A-	A	Alge I B 5	Alge II C 5
Music	A	B+	Chorus B	Chorus A	Chorus A 5	Chorus A 5
Science	A				Sci I B 5	Sci II B 5
Social Studies	World Geography and History	World Geography and History A	U.S. History and Geography A	U.S. History and Geography B	Ancient/Modern World History and Geography C 5	Ancient/Modern World History and Geography C 5
Physical Education	A	A	C	C	A 5	A

JUNIOR HIGH SCHOOL GRADUATION [ ] SPECIAL TO HIGH SCHOOL [ ] DATE

TOTAL HIGH SCHOOL UNITS

SENIOR HIGH SCHOOL

EXPLANATION OF MARKS

SUBJECT:
- A SUPERIOR
- B ABOVE AVERAGE OR GOOD
- C AVERAGE
- D BARELY PASSING
- F FAILURE

GRADUATION REQUIREMENTS

ENGLISH III, IV, V, 12	20 SEM. CR.	PHYSICAL EDUCATION	EVERY SEM. CR.
U.S. HISTORY I, II CIVICS	15 SEM. CR.	ARITHMETIC	5 SEM. CR.
WORLD GEOGRAPHY	5 SEM. CR.	LAB. SCIENCE	10 SEM. CR.
PERS. DEV. VOCATIONS DRIVER EDUCATION	5 SEM. CR.	INDIVIDUAL PROG. or MAJOR 20-30 SEM. CR. (150 Sem. Cr. or 15 units in addition to Physical Education Every Semester)	

COMPLETION OF GRADUATION REQUIREMENTS

DATE OF GRADUATION FROM SENIOR HIGH: June 20, 1969

NO. IN GRAD. CLASS: 840 Rank - 64

Scholarship Rating { Upper / Lower } 5th 4th 3rd Half

Grade	B10	A10	B11	A11	B12	A12
School	SANTA MONICA HS	SANTA MONICA HS	SANTA MONICA HS	SANTA MONICA HS	SANTA MONICA HS	SANTA MONICA HS
Date of Entering	9-19-66	2-6-67	9-11-67	1-29-68	9-16-68	2-3-69
Date of Leaving	2-3-67	6-22-67	1-26-68	6-14-68	1-31-69	6-20-69
Attendance (Absence)	0	4	11	6	11	17
Citizenship Record						
Subject	Course Title / Mark / Units	Course Title / Mark / Units	Course Title / Mark / Units	Course Title / Mark / Units	Course Title / Mark / Units	Course Title / Mark / Units
Art					Photo I B 5	Photo II C 5
Business Education						
English	Eng 3X A 5	Eng 4X A 5	Eng 5X A 5	Comp. X A 5	HONORS Eng 12 A 5	HONORS W.W. Ideas A 5
Foreign Language	French 3X B 5	French 4X B 5			German IX C 5	German 2 B 5
Home Making						
Industrial Arts						
Mathematics	Geom 1X A 5	Geom 2X A 5	Int. Math 1 & Trig. B 5			
Music						
Science		Biol 2X B 5	Physics 1X A 5; Biol 3X B 5	Physics 2X A 5; Biol 4X B 5	Chem 1X B 5	Chem 2X C 5
Social Studies	Biol 1X A 5; Survey of Socio Rec. A 5	Geog X A 5	Hist 1X A 5	US Hist 2X A 5	Government of United States B 5	[illegible] C 5
Physical Education	B -	B -	B -	B -	B -	B -
	Member C.S.F.	Member C.S.F.	Member C.S.F.	Member		

[redacted]

DATE	TRANSCRIPT SENT TO	DATE		GRADE	HONORARY POSITIONS
12-24-68	University of California - Davis	1-6-69			
12-24-68	Univ. of Calif. - Davis - Fiancial Aids				
1-9-69	Calif 4-H Scholarship				
12-26-69	University of Calif. - Los Angeles Financial Aids				HEALTH
1-6-69	California State Scholarship Committee				

SCHOLASTIC CAPACITY TESTS

Date	Grade	TEST	Form	C.A.	LANG. VERBAL	NON-LANG. PERFORM.	TOTAL INDEX	X.A.

ACHIEVEMENT TESTS

Date	Grade	TEST	Form	READING—Gr. Pl. or %ile VOC.	COMP.	Total Gr. Pl.	Arithmetic—Gr. Pl. or %ile REAS.	FUND.	Language	Spelling	Other Tests

```
[redacted]   [redacted] GR   V    R    L1  L2  L3  L4    W1  W2  W3    A1  A2
ITBS 2       GE   9.1  127  110  121 104 125 110   118 122 110   108  96
10-65                  99%  94%  97% 76% 98% 86%   97% 99% 89%   91% 72%
[redacted]   HF   IQ        COMP       AL          AW            AA
             143  141       114 97%    115 94%     117 98%       102 84%
```

LAST [redacted] FIRST [redacted] M.I.

0768 EN653 BY699 AH615 11

COLLEGE ENTRANCE EXAMINATION BOARD

FATHER [redacted] ADDRESS [redacted]

MOTHER [redacted] ADDRESS

[redacted]

```
[redacted]   [redacted] GR   V    R    L1  L2  L3  L4    W1  W2  W3    A1  A2
ITBS 2       GE   7.2  116  113   99  99 112 106   101  94  92    88  84
11-63                  99%  99%  96% 91% 98% 97%   99% 97% 94%   96% 90%
[redacted]   HF   IQ        COMP       AL          AW            AA
             109  148       103 99%    104 98%     96 98%        86 94%

TAP          10/66  GR  SS COMP  SCI READ MATH  LIT  TT
[redacted]   [redacted] 10.1         61
FORM 1                               93/8
L-TH G1      10/66  GR  CAGP MAGP  V   NV  AVIQ  V%  NV% AVG% VS9 NVS9
[redacted]   [redacted] 10.1 9.8 12.1 138         98           9
```

LAST [redacted] FIRST [redacted] M.I. [redacted]

683 502 1168 12

COLLEGE ENTRANCE EXAMINATION BOARD

```
CALIF PHYS PERF AGE   GR   SEX  PULL SIT  PUSH 50YD SBJ  BR-J RUN  SHR
[redacted]      15-00 10.2  2    NP   25   28   81   70   72   223  NP
     11/66 %TS                    30   75   45   20   75   75
```

Appendix C

TESTING PROGRAM, 1968-69, SANTA MONICA SCHOOL DISTRICT
SANTA MONICA, CALIFORNIA

Date for Administering	Grade	School	Name of Test
Oct 7-11	4	All elementary schools	ITBS - Form 2 (Red)
Oct 7-11	5	All elementary schools	ITBS - Form 1 (Blue)
Oct 7-11	6	All elementary schools	Stanford Reading Intermediate II - Form W
Oct 14-18	5	All elementary schools	Lorge Thorndike - Form 1 Level C - V & N-V
Oct 14-18	6	All elementary schools	Lorge Thorndike - Form 1 Level D - V & N-V
Oct 14-25	4,5,6	All elementary schools	ITBS, Stanford, Lorge Thorndike--Pick-ups
Oct 7-11	8	Adams	Lorge Thorndike - Form 1 Level F - V & N-V
Oct 14-18	7,9	Adams	ITBS-Form 2 (Red)
Oct 14-18	8	Adams	ITBS - Form 1 (Blue)
Oct 14-25	7,8,9	Adams	Pick-up Testing
			Lorge Thorndike - Form 1
Oct 7-11	8	Lincoln	Level F - V & N-V
Oct 14-18	7,9	Lincoln	ITBS - Form 2 (Red)
Oct 14-18	8	Lincoln	ITBS - Form 1 (Blue)
Oct 14-25	7,8,9	Lincoln	Pick-up Testing
Oct 7-11	7,9	Malibu Park	ITBS - Form 2 (Red)
Oct 7-11	8	Malibu Park	ITBS - Form 1 (Blue)
			Lorge Thorndike - Form 1
Oct 14-18	8	Malibu Park	Level F - V & N-V
Oct 14-25	7,8,9	Malibu Park	Pick-up Testing
			Lorge Thorndike - Form 1
Oct 7-11	10	Samohi	Level G - V & N-V
			Tests of Academic Progress
Oct 14-18	10	Samohi	Form 1 - Reading Section
Oct 14-25	10	Samohi	Pick-up Testing
May 1-14	1	All elementary schools	Stanford Reading Test Form W, Primary I
May 1-14	2	All elementary schools	Stanford Reading Test Form W, Primary II
May 1-14	3	All elementary schools	Stanford Reading Test Form X, Primary II

APPENDIX D

Appendix D contains cost estimates for carrying out student scheduling, master scheduling, attendance reporting, grade reporting, and master file maintenance using a remote batch processing system. Costs using remote readers and line printers may be expected to be somewhat higher. This depends, however, upon extent of usage, since these costs are based on hourly charges for central line printers, while remote usage costs depend on usage per month, in relation to monthly rental charges. The transactions which together make up these activities are listed along with the input, output, description, frequency, cost per transaction and cost per pupil.

The information for transaction input, output and description comes mainly from Tables 6.20-6.24 of Feasibility Study of a Central Computing Facility. (11, pages 54-56.) This feasibility study used 100,000 students for its population size. In obtaining the transaction cost and per pupil cost, we also assumed 100,000 students.

These cost estimates assumed the characteristics of equipment as given below:

REMOTE EQUIPMENT

Teletypewriter	10 characters/second
Line printer	300 lines/minute
Card reader	100 cards/minute

CENTRAL EQUIPMENT

Line printer	800-1200 lines/minute
Card reader	800 cards/minute
Card punch	400 cards/minute
Magnetic tape	75 inches/second @ 556 bpi
Disk units	100,000-200,000 charac/ters/second

Cost Estimates for Time-Sharing Services

Costs for a system involving time sharing with a remote configuration are based on four kinds of costs:

a. Terminal equipment at remote sites (fixed rental costs)

b. Connect time charges by computer time-sharing services

c. Central processing unit charges

d. Disk storage charges

The storage costs (d) are difficult to estimate, because they depend on the relative use of magnetic tape storage, which has negligible cost but should not be used for records needing daily access, and disk storage, which is costly.

To estimate costs for a school system with 10,000 students, fixed and variable charges are estimated below.

1. Fixed Charges

2 high schools, 2000 students each		
3 TTY @ $70/mo.	$210	
1 card reader @ $160/mo.	160	
1 line printer @ $400/mo.	400	
	$770 x 2 =	$1540
8 elementary schools, 750 students each		
2 TTY @ $70/mo.	$140	
1 card reader @ $160/mo.	160	
	$300 x 8 =	$2400
District office (same as high school)		$ 770
		$4710/mo.

2. Connect Time and Central Processing Unit Charges

Current charges in commercial time-sharing systems range from about $6.50/hr. to $10/hr. connect time, with cpu time ranging from $ .03/second to $ .10/second, depending on the capability of the central processing unit. For many school applications, the principal activity involved is printing, with very little central processing time.* For an application involving grade reporting as an example, time charges would be something like this for a 2000-student high school.

---

*In some time-sharing systems, the central processor is used for auxiliary functions such as printing, thus adding cpu charges to connect time charges. Because of this, for applications such as those under consideration in this report, systems which use auxiliary processors for input and output operations should be used.

$$\frac{\text{2000 students x 15 lines/student}}{\text{200 x 60 lines/hour}} = \text{2.5 hours}$$

2.5 hours x $7.50 = $22.50/grade report for 2000 students

In the 10,000 student district, time charges would be $111.50 per reporting period, or $ .01/student.

It is clear from these estimates that for most pupil personnel activity, which involve principally input and output procedures, the time charge will likely be a smaller part of the total cost than terminal equipment.

D.1. SCHEDULING

Transaction	Input	Output	Description	Frequency	Cost/Transaction	Yearly per pupil cost
Creation of working file	1 card per student	1 record per student	Students submit cards with course requests and working file is created from these cards.	2 times per year	$300	$.006
File edit	1 record per student	10 lines per student	Working file is edited for these errors -- prerequisites and loading -- and then each student's requests with comments are printed.	2 times per year	$1660	$.033
Course lists	1 record per student	1 line per requestor	File is searched to determine the number of requests for each course.	2 times per year	$50 (dependent upon the number of courses offered. For 20,000 different course offerings; 20,000 lines would be printed)	$.001
Course changes	1 card per change	1 line per change	Correction and changes are read and edit performed.	2 times per year	$17 (10% course changes)	$.0003

D.1. SCHEDULING (CONT.)

Transaction	Input	Output	Description	Frequency	Cost/Transaction	Yearly per pupil cost
Tally	1 card per course	1 line per course	Final tally of number of requests per course.	2 times per year	$50 (20,000 courses)	$.0010
Cross-tally		30 lines per course	Cross tally of requests	2 times per year	$500 (600,000 lines)	$.0300
Creation of Master Schedule	1 document course			2 times per year	Cannot estimate	
Assignment simulation	(working file)	15 lines per conflict	Prints conflicts	2 times per year	$40 (5% conflict rate = 5000 students, 75,000 lines)	$.0024
Student schedule		10 lines per student	Print student schedule	2 times per year	$1660	$.0332
Class list	Student schedules	1 line per student per course	Find requested list	2 times per year	$300	$.06
Home room list	Student schedules	1 line per student	Find requested list	2 times per year	$300	$.06
Study hall list	Student schedules	1 line per student per study hall	Find requested list	2 times per year	$300	$.06

D.2. ATTENDANCE DATA

Transaction	Input	Output	Description	Frequency	Cost/Transaction	Yearly per pupil cost
Generation of attendance reporting document	Student master file	1 card per student	A mark-sense card with pre-punched identification code is generated for each student.	1	$950	$.095
Posting daily absentees	1 card per absentee	4 lines per absentee and writing of work file	Cards of absent students are read and printed for 1. teachers 2. counselors 3. central office 4. special reports	Daily or 178 times	$8.35 (10% absentee rate)	$.015
Updating master file with attendance data and printing summary reports	Working file containing attendance information	Updated working file and reports of: 1. Summary per student 2. District summary	The working file with daily attendance information is read and used to update the master file. At the same time student attendance profiles and district summaries are printed.	4 times per year	$300 per update	$.012

D.3. REPORT CARDS

Transaction	Input	Output	Description	Frequency	Cost/Transaction	Yearly per pupil cost
Generation of grade marking cards	1 record student	7 cards/ student	A set of mark-sense cards is generated for each student having his name and course pre-punched in each card.	8 times/year	$9500: $700 (10 cards per student)	$ .176
Reading and printing of returned grades	10 cards/ student	10 lines student	Initial printing of grades to be sent to teacher for verification	8 times/year	$1660	$ .130
Correction of report cards	1 card correction	1 line correction	Errors in work file are corrected	8 times/year	$17 (10% error rate assumed)	$ .0014
Print report cards and update master file	3 records	20 lines student	Read student master file for address of parents, working report file for grades, print grades and addresses	8 times/year	$3600	$ .28

D.3. REPORT CARDS

(Continued)

Transaction	Input	Output	Description	Frequency	Cost/Transaction	Yearly per pupil cost
Printing failure or incomplete list	Working file	List of failures	Working file is read and list of failures and incompletes made up	8 times/year	$17 (10% of students)	$ .0014
Printing honor roll	Working file	List of honor roll students	Working file is read and list of honor roll students is printed	8 times/year	$17 (10% of students)	$ .0014
Rank in class	Working file	Sorted working file	Working file must be sorted by students grade point average	8 times/year	$300	$ .024
Mark distribution	1 record/student	20 lines/teacher	Distribution of grades for each teacher is computed and printed	8 times/year	$150 (4000 teachers)	$ .012

D.4. TESTING

Transaction	Input	Output	Description	Frequency	Cost/Transaction	Yearly per pupil cost
Document preparation	Master file	2 cards per student	Cards are prepunched with identifiers	2 times/year	$1900 (200,000 cards)	$.038
Scoring	2 cards per student (answer cards)	1 record per student	Answer cards are read	2 times/year	$500	$.01
Report Generation	1 record per student	1 line per student	Request cards are read and report printed	2 times/year	$400 (100,000 lines)	$.008
Gummed labels	1 record per student	2 lines per student	Gummed labels for hard copy	2 times/year	$700 (200,000 lines)	$.014
Make-up test	2 records per student	1 line per absentee	Generation of names of student not taking test	2 times/year	$17.00 (10% of students absent x 100,000 = 10,000)	$.0003
Item analysis	2 cards per student	200 lines per test	For teacher made test	---	(200 x 100,000 10 million lines)	---

D.5. MAINTENANCE AND RETRIEVAL OF MASTER FILE

Transaction	Input	Output	Description	Frequency	Cost/Transaction	Yearly per pupil cost
File update	1. Updates (1 record per student) 2. Master file	Updated student file	Updates are [illegible] and student files are updated	20 times* per year	$300 (tape file stored 556 bpi read at 75 inches per second)	$.06
Complete file print	Master file	40 lines per student	Complete listing of master file	2 times per year	$7000 (using 1000 lpm printer requires 70 hours)	[illegible].14
Partial file print	1. Selector requests 2. Master file	3 lines per student	Retrieve data requested by input card, print results	20 times per year	$700 (using 100 lpm printer requires 7 hours)	$.14

*The number of file updates includes addition of grade report data at 5-week intervals and standardized test reporting twice a year.

APPENDIX E

EDUCATIONAL RETRIEVAL SYSTEM*

The user (e.g., administrator, counselor, teacher, or researcher) can communicate with his data base in two different ways. In the off-line method, the user expresses his retrieval and analysis requirements on standardized forms, with the aid of a dictionary describing the data in his system. The forms are keypunched, fed to the computer and later the user receives his easy-to-read reports. In the on-line or interactive method, the user sits at a typewriter terminal linked to a computer. The computer and user carry on a conversation in which the computer tells the user what data elements are in the data base and what statistics or lists he can obtain. The user specifies what he wants by answering questions and the computer immediately produces his reports and statistics. Neither the off-line nor interactive method requires a programmer to help the user specify the students he wants included in his reports, the data elements he wants used, or the choice of statistics that are to be computed.

This general purpose system could be used by administrators and counselors with their historical data base to conveniently answer pertinent questions such as: Which seniors have not completed all of the requirements for the State University? How many students scored below the 20th percentile on the math achievement test? or: Which students are eligible for Honors English? Counselors could use the system for individual program planning and to relate the student's performance to specific group norms, or college entrance requirements. Researchers could use these historical data bases with this general purpose system to study relationships between early measures of behavior and subsequent performance.

---

*Designed and written by Barbara Marks, Management Sciences Department, using RAND's JOSS interactive computer system.

```
Pick one of these modes:
1) Build a data base or add students to an exisiting data base.
2) Change the existing data base.
3) Querry the existing data base.
Your Choice = 1


                    OPTIONS AVAILABLE

              1.  Input Student data

              2.  Change  Student data

              3.  Describe correlations

              4.  Compute correlations

              5.  Describe new Student attributes

              6.  List Student data

              7.  Finish


Choose one of the following:
1) Adding more students to an existing item.
2) Adding a new item to an existing data base.
3) Building a new data base.
Your Choice = 1

      The characteristics of students stored in item 10 are:
      Student ID's range from    2767 to 993142.
      Sex:  1 = male, 2 = female, is from 1 to 1.
      Students are in sample 1 to 1.
      Number of years students were in the system range from 4 to 4.
      Students were in school 2 to 3.

      The characteristics of students stored in item 11 are:
      Student ID's range from    3223 to 993826.
      Sex:  1 = male, 2 = female, is from 1 to 1.
      Students are in sample 2 to 2.
      Number of years students were in the system range from 4 to 4.
      Students were in school 2 to 3.

      The characteristics of students stored in item 12 are:
      Student ID's range from    1000 to 994054.
      Sex:  1 = male, 2 = female, is from 2 to 2.
      Students are in sample 3 to 3.
      Number of years students were in the system range from 4 to 4.
      Students were in school 2 to 3.

      The characteristics of students stored in item 13 are:
      Student ID's range from    9607 to 994282.
```

Sex: 1 = male, 2 = female, is from 2 to 2.
Students are in sample 4 to 4.
Number of years students were in the system range from 4 to 4.
Students were in school 2 to 3.

Item Number = 10

Option = 6

```
Describe the characteristics of the sample you want included
Do you want all students included? (y or n) = n
Specify the restrictions on the sample.  For each
attribute number include a comparison operator and the
limiting value.
You may specify the same attribute more than once.

Stud ID   Sex   Sam   Yrs   Sch   Grade   Pt     Ave    DAT      STEP
                                    9    11-12   ALL   V   N    R   M
Code 1     2     3     4     5     6      7      8     9  10   11  12

The comparison operators are: 1=equal,2=not equal,3=less than,4=greater than

Attribute Number = 8
Comparison Operator = 4
Value = 3.5

Include students whose attribute number  8 is greater than  3.50.

Is this correct? (y or n) = y

Any more restrictions? (y or n) = n
```

Stud ID	Sex	Sam	Yrs	Sch	Grade 9	Pt 11-12	Ave ALL	DAT V	DAT N	STEP R	STEP M
57031	1	1	4	3	3.58	3.76	3.51	36	30	63	45
127768	1	1	4	3	3.43	3.60	3.57	38	33	61	40
256189	1	1	4	2	3.93	3.82	3.88	37	36	65	41
378810	1	1	4	3	3.17	3.80	3.52	35	18	59	34
406555	1	1	4	2	3.83	3.68	3.61	22	18	58	41
679300	1	1	4	2	3.30	3.47	3.56	42	38	64	42
828283	1	1	4	2	3.50	3.65	3.55	23	15	56	37
971339	1	1	4	2	3.92	3.93	3.70	40	33	67	46
330517	1	2	4	2	3.75	4.00	3.69	25	27	55	38
380734	1	2	4	2	3.83	3.88	3.73	36	22	62	44
619735	1	2	4	2	4.00	3.80	3.89	15	24	50	29
766061	1	2	4	2	3.83	3.76	3.61	30	25	58	36
925369	1	2	4	2	3.85	3.60	3.74	30	25	64	37
85132	2	3	4	2	3.43	3.67	3.51	18	15	58	24
135375	2	3	4	2	3.79	3.76	3.63	40	27	60	33
140593	2	3	4	2	3.83	3.41	3.66	18	23	55	16
275113	2	3	4	3	3.83	3.87	3.64	33	33	63	40
378226	2	3	4	2	3.58	3.93	3.62	16	25	60	24
406270	2	3	4	3	3.25	3.63	3.51	26	28	66	28
665021	2	3	4	3	3.50	3.61	3.59	26	26	62	31
737896	2	3	4	2	3.71	3.59	3.67	29	34	62	32
820261	2	3	4	3	3.70	3.41	3.53	40	38	65	43

Stud ID	Sex	Sam	Yrs	Sch	Grade 9	Pt 11-12	Ave ALL	DAT V	DAT N	STEP R	STEP M
823624	2	3	4	3	4.00	3.82	3.79	28	31	63	36
~~828298~~	~~2~~	~~3~~	~~4~~	~~2~~	~~3.57~~	~~3.53~~	~~3.55~~	~~17~~	~~31~~	~~47~~	~~29~~
950967	2	3	4	3	3.92	3.73	3.64	29	30	61	31
963425	2	3	4	2	3.75	3.93	3.78	15	13	60	22
994054	2	3	4	3	3.92	3.60	3.62	21	23	56	30
36112	2	4	4	2	3.75	3.53	3.53	36	32	56	39
85075	2	4	4	2	3.67	3.60	3.67	26	16	56	23
96247	2	4	4	3	3.50	3.53	3.55	26	19	62	32
101548	2	4	4	2	3.71	3.71	3.71	34	32	62	29
205915	2	4	4	2	3.57	3.53	3.58	22	24	56	23
213040	2	4	4	3	3.83	3.59	3.59	25	39	58	42
316837	2	4	4	3	3.75	3.67	3.72	34	29	60	33
485871	2	4	4	3	3.85	4.00	3.92	41	29	65	34
495646	2	4	4	2	4.00	4.00	3.98	44	36	68	35

Option = 5

```
New attributes are computed as a function of constants
operators and already defined attribtues.
These new attributes can be used to compute more attributes.
Attributes already in the system are

Stud ID   Sex   Sam   Yrs   Sch   Grade   Pt      Ave    DAT       STEP
                                    9     11-12   ALL    V   N     R    M
Code 1     2     3     4     5     6       7       8     9   10    11   12

The arithematic operators are: 1 = add, 2 = subtract,
3 = multiply, 4 = divide.
New attributes are evaluated form left to right.
An operator value of 0 indicates that you have completed
the inputs for deriving this attribute.

Choose one:  1 = constant value, 2 = attribute number
Your choice = 2
Attribute Number = 9
Operator = 1
Choose one:  1 = constant value, 2 = attribute number
Your choice = 2
Attribute Number = 10
Operator = 0

Attribute Number 13 = Attribute Number  9
                                  + Attribute Number 10

Is this correct? (y or n) = y
Another attribute?  (y or n) = y

Choose one:  1 = constant value, 2 = attribute number
Your choice = 2
Attribute Number = 11
Operator = 1
Choose one:  1 = constant value, 2 = attribute number
Your choice = 2
Attribute Number = 12
Operator = 0

Attribute Number 14 = Attribute Number 11
                                  + Attribute Number 12

Is this correct? (y or n) = y
Another attribute?  (y or n) = n


Option = 3
```

```
Select the attributes you want to correlate.  Input attribute
number or 0 if you have completed your selections.

Stud ID   Sex   Sam   Yrs   Sch   Grade   Pt     Ave    DAT     STEP
                                    9     11-12  ALL   V   N    R    M
Code                                6      7      8    9  10   11   12

Attribute Number 13 = Attribute Number  9
                                  + Attribute Number 10

Attribute Number 14 = Attribute Number 11
                                  + Attribute Number 12

Attribute number = 6
Attribute number = 7
Attribute number = 8
Attribute number = 9
Attribute number = 10
Attribute number = 11
Attribute number = 12
Attribute number = 13
Attribute number = 14
Attribute number = 0

The attributes you have selected are
              6
              7
              8
              9
             10
             11
             12
             13
             14
Is this correct? (y or n) = y


Describe the characteristics of the sample you want included
Do you want all students included? (y or n) = n
Specify the restrictions on the sample.  For each
attribute number include a comparison operator and the
limiting value.
You may specify the same attribute more than once.

Stud ID   Sex   Sam   Yrs   Sch   Grade   Pt     Ave    DAT     STEP
                                    9     11-12  ALL   V   N    R    M
Code 1     2     3     4     5      6      7      8    9  10   11   12

The comparison operators are: 1=equal,2=not equal,3=less than,4=greater than
```

Attribute Number = 3
Comparison Operator = 1
Value = 1

Include students whose attribute number 3 is equal to 1.00.

Is this correct? (y or n) = y

Any more restrictions? (y or n) = n

Option = 4

Correlations

Stud ID	Sex	Sam	Yrs	Sch	Grade 9	Pt 11-12	Ave ALL	DAT V	DAT N	STEP R	STEP M
Code 1	2	3	4	5	6	7	8	9	10	11	12

Correlation	Attr. No.	Mean	S.D.	Atrr. No.	Mean	S.D.	No.
.67	6	2.37	.59	7	2.28	.62	165
.84	6	2.37	.59	8	2.40	.56	165
.47	6	2.37	.59	9	16.18	9.06	165
.47	6	2.37	.59	10	15.61	8.81	165
.48	6	2.37	.59	11	44.66	11.35	165
.52	6	2.37	.59	12	24.90	8.26	165
.51	6	2.37	.59	13	31.78	16.38	165
.53	6	2.37	.59	14	69.56	18.16	165
.90	7	2.28	.62	8	2.40	.56	165
.44	7	2.28	.62	9	16.18	9.06	165
.48	7	2.28	.62	10	15.61	8.81	165
.50	7	2.28	.62	11	44.66	11.35	165
.52	7	2.28	.62	12	24.90	8.26	165
.51	7	2.28	.62	13	31.78	16.38	165
.55	7	2.28	.62	14	69.56	18.16	165
.51	8	2.40	.56	9	16.18	9.06	165
.58	8	2.40	.56	10	15.61	8.81	165
.56	8	2.40	.56	11	44.66	11.35	165
.61	8	2.40	.56	12	24.90	8.26	165
.59	8	2.40	.56	13	31.78	16.38	165
.63	8	2.40	.56	14	69.56	18.16	165
.68	9	16.18	9.06	10	15.61	8.81	165
.76	9	16.18	9.06	11	44.66	11.35	165
.70	9	16.18	9.06	12	24.90	8.26	165
.92	9	16.18	9.06	13	31.78	16.38	165
.79	9	16.18	9.06	14	69.56	18.16	165
.63	10	15.61	8.81	11	44.66	11.35	165
.72	10	15.61	8.81	12	24.90	8.26	165
.91	10	15.61	8.81	13	31.78	16.38	165
.72	10	15.61	8.81	14	69.56	18.16	165
.71	11	44.66	11.35	12	24.90	8.26	165
.76	11	44.66	11.35	13	31.78	16.38	165
.95	11	44.66	11.35	14	69.56	18.16	165
.78	12	24.90	8.26	13	31.78	16.38	165
.90	12	24.90	8.26	14	69.56	18.16	165
.83	13	31.78	16.38	14	69.56	18.16	165

Sample Characteristics

Include students whose attribute number 3 is equal to 1.00.

Attribute Number 13 = Attribute Number 9
+ Attribute Number 10

Attribute Number 14 = Attribute Number 11
+ Attribute Number 12

Option = 1

Student I.D. = 236741
Sex, Male = 1, Female =2. = 2
Sample student assigned to. = 3
Number of years in system. = 3
High school attended = 2
Verbal score on DAT. = 23
Numerical score on DAT. = 35
Reading score on STEP. = 42
Math score on STEP. = 31
Overall Grade Point Average. = 3.21
9th Grade Grade Point Average excluding P.E. = 3.56
11-12th Grade Grade Point Average excluding P.E. = 3/42

Stud ID	Sex	Sam	Yrs	Sch	Grade	Pt	Ave	DAT		STEP	
					9	11-12	ALL	V	N	R	M
236741	2	3	3	2	3.56	.07	3.21	23	35	42	31

Is this correct? (y=yes, n=no). = n
Input more data this item? (y or n). = n
Input more data this data base? (y or n). = n

Option = 7

Please turn me off. Thank you.

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